CANADA

DEPARTMENT OF MINES

HON. ALBERT SÉVIGNY, ACTING MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

MINES BRANCH

EUGENE HAANEL, PH.D., DIRECTOR.

Iron Ore Occurrences in Canada

IN TWO VOLUMES

COMPILED BY

E. Lindeman, M.E.

and

L. L. Bolton, M.A., B.Sc.

Introductory

BY

A. H. A. Robinson, B.A.Sc.

VOL. I.

DESCRIPTIONS OF PRINCIPAL IRON ORE MINES.

OTTAWA

GOVERNMENT PRINTING BUREAU

1917

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IRON ORE OCCURRENCES IN CANADA.

INTRODUCTORY.

BY

A. H. A. Robinson, B.A.Sc.

IRON ORE OCCURRENCES IN CANADA.

INTRODUCTORY.

References to Canadian iron ore deposits are of frequent occurrence in mining and scientific literature, and many excellent descriptions of individual deposits and districts have been published from time to time. With the exception of two or three short papers, however, no attempt has been made to bring together all this scattered and fragmentary information, and put it in a form at once compact and readily accessible for reference to those interested.

Some years ago, the preparation of a report with this end in view was undertaken by Mr. Einar Lindeman, acting under instructions from the Director of the Mines Branch, in connexion with a general investigation then being carried on into Canada's iron ore resources. Before this work was completed, however, a Committee, of which Mr. Lindeman was a member, was appointed by the Government to make a special report on the condition of the iron mining industry in Canada; and collected, as a part of its work, considerable information—much of it hitherto unpublished—concerning Canadian iron deposits. The combined information: that collected by the Committee itself, and that previously prepared by Mr. Lindeman for a Mines Branch report, was then compiled by Mr. L. L. Bolton, and incorporated as a part of the Report of the Committee on the Iron Industry. This part of the Committee's report contains a very complete summary of the available information respecting iron ore occurrences in Canada, hence was placed at the disposal of the Director of the Mines Branch for publication.

With the exception of such minor changes as were necessary to prepare it for publication, no alterations have been made in Mr. Bolton's work. References to various magnetic survey maps prepared by officers of the Mines Branch since 1903 have been added.

The report is divided into two parts: Vol. I contains descriptions of the principal iron mines in Canada, to which there has been added, in a supplement, a description of the Wabana mines in Newfoundland: of interest in this connexion, since they are controlled, operated, and their ores largely used by Canadian corporations. Vol. II contains descriptions of Canadian iron ore occurrences in general.

The arrangement throughout is geographical, the grouping being by Provinces and their subdivisions, proceeding in order from west to east. The individual occurrences are, as a rule, described separately, and each description is followed by a list of the authorities on which it is based.

The great importance of obtaining as full a knowledge as possible of our iron ore resources was early recognized, and, in 1903, the systematic

investigation of Canada's iron ore deposits was first set on foot by the present Director of the Mines Branch, Dr. Eugene Haanel, at that time Superintendent of Mines for Canada. From that time up to the present this work has been carried on continuously under his direction, and bulletins and maps covering different iron mines and iron mining districts have been issued to the public as the work progressed.

The Mines Branch, in its investigations, has given particular attention to the magnetometric surveying and mapping of deposits of magnetite. This has been done for several reasons: (1), because it was desired to introduce a method for the investigation of magnetic ore deposits that had been found particularly useful in a country like Sweden, but which was practically unknown in Canada; (2), because by this method definite information concerning the extent and shape, and hence, in some degree, the value of our numerous known deposits of magnetite could be more readily obtained than in any other way; (3), because the maps made in the course of these surveys would be of considerable service as guides in the exploration and development of such of the deposits as seemed worthy of further attention; and (4), because work of this kind would have no tendency to overlap but would be entirely supplementary to that of other investigators. As a result of this magnetometric work much definite knowledge concerning our magnetite deposits has been secured, and erroneous impressions regarding the continuity and extent of some of them corrected.

Copies of the magnetometric and topographical maps made in the course of this work, a list of which will be found in the table of contents, accompany this report.

GENERAL STATEMENT.

Discovery of iron ore in Canada is recorded as early as 1667; and in 1733 there was already one forge in operation. This earliest plant was succeeded in 1737 by a group of forges at Three Rivers, Quebec, which remained in active operation almost continuously until 1882, being at that time the oldest active iron producers in America. A number of other small plants were erected at various points in Canada during the latter part of the eighteenth, and the earlier part of the nineteenth centuries; but the iron industry did not assume any large proportions, or commence to take on its modern form until 1896. Since then its growth has been rapid.

In the earlier days, when the iron industry was small, sufficient ore was available locally to meet all the demands of the furnaces. Since 1896, however, this condition of affairs has changed; both the production of iron ore and its consumption in blast furnaces have increased; but the latter so much more rapidly than the former that in 1916 the total production of iron ore in Canada was only equal to 15·5 per cent of the total ore smelted in Canadian blast furnaces.

The part played by native ores in Canada's iron industry is indicated in the following table. The last column, showing the ratio of total production to consumption in blast furnaces, has been added as giving, perhaps, a fairer view of the situation than the column preceding; since that portion of the total production not used in Canadian furnaces will offset an equal amount of imported ore so used.

Iron Ore Utilized in Canada during the Years 1887-1916.

Calendar Year.	Production of iron ore in Canada.	Iron ore charged to Canadian blast furnaces.			Canadian ore in total ore charged.	Ratio Canadian production to total ore charged.
	Short tons.	Canadian. Short tons.	Imported. Short tons.	Total. Short tons.	Per cent.	Per cent.
1887....	76,330	60,434	....	....	....	....
1888....	78,587	54,956	....	....	....	....
1889....	84,181	65,670	....	....	....	....
1890....	76,511	57,304	....	....	....	....
1891....	68,979	60,933	....	....	....	....
1892....	103,248	96,948	....	....	....	....
1893....	125,602	124,053	....	....	....	....
1894....	109,991	108,871	....	....	....	....
1895....	102,797	93,208	....	....	....	....
1896....	91,906	96,560	46,300	142,860	67·6	64·3
1897....	50,705	53,658	55,722	109,380	49·0	46·3
1898....	58,343	57,881	77,107	134,988	42·9	43·2
1899....	74,617	66,384	120,650	187,034	35·5	39·9
1900....	122,000	71,341	112,042	183,383	38·9	66·5
1901....	313,646	156,613	361,010	517,623	30·2	60·6
1902....	404,003	125,664	559,381	685,045	18·3	58·9
1903....	264,294	82,035	485,911	567,946	14·4	46·5
1904....	219,046	180,932	454,671	635,603	28·4	34·4
1905....	291,097	116,974	861,847	978,821	12·0	29·7
1906....	248,831	221,733	982,740	1,204,473	18·4	20·7
1907....	312,856	244,104	1,117,260	1,361,364	17·9	22·9
1908....	238,082	209,266	1,051,445	1,260,711	16·6	18·8
1909....	268,043	231,994	1,235,000	1,466,994	15·8	18·3
1910....	259,418	149,505	1,377,035	1,526,540	9·8	17·0
1911....	210,344	67,434	1,628,368	1,695,802	4·0	12·4
1912....	215,883	71,588	2,019,165	2,090,753	3·4	10·3
1913....	307,634	139,436	2,110,828	2,250,264	6·2	13·7
1914....	244,854	182,964	1,324,326	1,507,290	12·1	16·2
1915....	398,112	293,305	1,463,488	1,756,793	16·7	22.6
1916....	339,600	221,773	1,964,598	2,186,371	10·1	15·5

N.B.—This table is compiled from the figures given in the annual reports of the Division of Mineral Resources and Statistics, of the Mines Branch, Ottawa.

Practically all the imported ore comes either from Wabana, Newfoundland, or from the Lake Superior iron ranges in the United States. It might be noted in passing, however, that the word "imported" has not the same significance as applied in the two cases. The Wabana ore, on which the Nova Scotian iron and steel industry is based, comes from a sister British colony, and is owned and mined by Canadian companies for use in their own furnaces; on the other hand, the Lake Superior ores

are owned and mined by United States interests, and are bought on the open market by the Ontario smelters.

At present, all the Canadian ore produced is the output of two mines, the Magpie and the Helen. Both are situated in the Michipicoten district, in Ontario, and both are owned and operated by the Algoma Steel Corporation of Sault Ste. Marie, Ontario.

In any consideration of Canada's iron ore resources, a point that should not be lost sight of, is that the total area comprised in the Dominion is very large, and that much of it is practically unexplored so far as its iron ore possibilities are concerned. By reference to the general map at the end of the volume, it will be seen that, with very few exceptions, all the known occurrences are situated in the older and more or less settled and known districts. In the comparatively unexplored regions of the north, large areas of iron bearing rocks occur at a number of points, but, on account of their inaccessible location, there is, at the present time, little to induce a thorough exploration of them in a search for ore bodies.

SUMMARY.

A summary review of the iron ore situation in the different provinces follows.

BRITISH COLUMBIA.

Up to the present the production of iron ore in British Columbia has been an almost negligible quantity. The total recorded from 1886 to 1903, both years inclusive, was only 62,578 tons; since 1903 the only production recorded was in 1907 when 2,500 tons were shipped.

Most of the ore—practically all magnetite—was sent to Irondale, Washington, U.S.A., where it was used in the production of pig-iron in a small charcoal blast furnace. The balance went to lead smelters to be used as flux.

The small production of British Columbia has been due, not so much to the lack of iron ore deposits, as to the lack of a market for the ore. In the absence of a local iron smelting industry, there has been no particular incentive either to develop the known ore-bodies, or to search for new ones.

The different varieties of iron ore found in British Columbia, include magnetites, hematites, limonite or bog ores, and clay ironstones.

Magnetite.—The most important of the known ore bodies are a series of magnetite deposits which occur on the islands along the coast in the western part of the Province. Among the better known localities in which these are found may be mentioned: Gordon river, Head bay, Klaanch river, and Quinsam river, in Vancouver island; Louise and Moresby islands, in the Queen Charlotte group; Texada island; and Redonda island. Promising deposits are also reported as occurring on other islands, and at various points on the coast, but little definite information is available regarding

them. In general character, all these deposits agree closely. The iron content is variable, ranging from 45 to 65 per cent. Phosphorus is often below the Bessemer limit; on the other hand, sulphur is usually so high that the ore would require preliminary roasting, to render it suitable for economic smelting. Most of the deposits carry copper in the form of chalcopyrite, and in portions of some of them at least, the quantity may be sufficient to constitute an ore of copper rather than of iron. Garnet, amphibole, and other silicates are abundant, and locally, in such quantities, that hand sorting of the ore is necessary.

Practically, all the ore bodies are located at or near the contact of limestone with igneous rocks, and genetically they are regarded as replacement deposits of the contact metamorphic type. As such, they are characteristically uncertain, and irregular in outline, and the association of ore and wall rock so variable that it is not safe to assume their extension beyond the zone of direct observation. Mining operations have not been extensive enough to determine their vertical shape and extent, or their mineralogical composition at depth.

Making due allowance, however, for lack of development, and for all doubtful and uncertain factors, it is still possible to say that there is in the aggregate, in the known magnetite deposits of the coast district of British Columbia, a sufficiently large tonnage of ore available to support a small local iron industry for many years when conditions justify its establishment. There is little doubt, also, that active exploration would disclose many bodies of iron ore at present unknown.

The coast magnetites, while somewhat handicapped by their composition, and while they will in most, if not in all cases require to be roasted before smelting, are capable of producing a good merchantable pig-iron. They can be easily and cheaply mined, and are located close to tide water. Besides an adequate supply of suitable ore, other important considerations in the establishment of an iron industry are the proximity of fuel and flux, the ease with which the raw materials can be assembled at the point of production, and a market for the product at profitable prices. On the British Columbia coast, ore, coke, and limestone suitable for flux, are all obtainable within easy reach of each other, and all are located so close to navigable water, open the year round, that transportation would be of the cheapest. These considerations suggest that the ores will ultimately be smelted locally; on the other hand, the labour situation in British Columbia is not the most favourable.

Failure to establish an iron smelter in the past has usually been ascribed to the lack of sufficient market for pig-iron; it is possible that the real limitation to the smelting of these ores locally will be found to be the cheapness with which Chinese and Indian pig-iron can be laid down on the coast market.

The only inland deposit of magnetite in British Columbia that has had much development work done on it is the Glen mine, on the south side of Kamloops lake. Previous to 1901, some 12,000 tons of magnetite were mined and shipped from this property to be used as a flux by lead smelters. Judging by the available records of analyses, the ore is of excellent quality, and while development is not sufficient to prove the reserve tonnage claimed (8,000,000 tons) there is apparently a considerable quantity available.

Hematite deposits have been found in a number of localities in British Columbia, notably, Bull river, Kitchener, and Chilcotin; but, while analyses indicate some ores of good quality, there is, as yet, no evidence that they are representative of bodies of sufficient size to be of commercial importance.

Limonite and *bog ores* are found at Quatsino sound on Vancouver island, on the headwaters of Summit creek in the Omenica mining division, on Lamb creek, and at various points in the Lillooet mining division. The more promising of these are the deposits at Summit creek, and at Quatsino sound.

At Summit creek the ore, a comparatively pure limonite, is of good grade, and should be especially valuable for mixing with the dense coast magnetites in the blast furnace. The full extent of the deposit is not known, but it is evidently large. At present it is too far from transportation to be available; the distance to Copper City on the Grand Trunk Pacific railway being about 38 miles.

The limonite and bog ore deposits found at Quatsino sound, while they have large areal extent, vary greatly in thickness, and appear, on the average, to be shallow. In 1907 an attempt was made to mine the ore on one of the most promising properties, and about 1500 tons were shipped. The average thickness of ore over the area worked was found, however, to be only about 24 inches, and the yield too small to be profitable.

Clay ironstone occurs to a limited extent, associated with the coal deposits of Vancouver island, but has not yet been reported in such quantity as to make it a probable source of iron. It is also found associated with the coal deposits in the Queen Charlotte islands, but in the undeveloped condition of these properties, it is impossible to form any idea of the quantity that might ultimately become available.

ALBERTA, SASKATCHEWAN, AND MANITOBA.

Up to the present time, no iron ore deposits of such size and quality as to make them of commercial value have been found in the Middle West provinces. There are, however, very large areas unprospected in all three, in which iron ores may be discovered in the future.

Several writers have drawn attention to the fact, that a steel plant located in western Alberta would have essentially the same location with reference to coal-fields and transportation routes as the Colorado Fuel and

Iron Company's plant at Pueblo, Colorado. The favourable situation with respect to the coal-fields and the growing industrial market of the prairie provinces should, therefore, make the discovery of even a moderately good iron ore deposit in this district, or in the adjoining portions of eastern British Columbia, a matter of more than ordinary importance.

At Burmis, near Blairmore in Alberta, beds of what appear to be consolidated black magnetic sands, are found. They carry in the neighbourhood of 40 per cent iron, and 5·5 per cent titanic acid, hence are not suitable for iron ore in their natural condition. Tests might show, however, the possibility of producing a commercial product from them by magnetic concentration.

At Black bay, on the north shore of Athabaska lake, in Saskatchewan, considerable areas of iron-bearing quartzites and conglomerates are reported to occur. So far as known the deposits are too low grade to be valuable, but the region has never been thoroughly explored, and were it not for its inaccessibility, would offer a promising field for the prospector of iron ore.

Hematite occurs on Black island in Lake Winnipeg, but a little prospecting work done on the deposit a few years ago gave only discouraging results.

Clay ironstones are found in numerous places throughout the three provinces, but nowhere in sufficient quantity to be of any value.

ONTARIO.

Ontario has to its credit the largest total production of iron ore of any of the Canadian provinces. Production by years and the total production to date are given in the following table, compiled from the figures given in the Annual Reports of the Ontario Bureau of Mines. For the period from 1869 to 1895 complete records are lacking; the amount set down being an estimate based on the best information available.

Previous to 1889, all the ore mined in the Province, with the exception of such small quantities as were used in the earlier attempts at iron smelting, was exported to the United States. From 1889 to 1895, both years inclusive, production ceased entirely. About 1896, a system of bounties inaugurated by the Federal and Provincial Governments to encourage the manufacture of iron and steel from native ores, had the desired effect of stimulating the industry, and the following years witnessed the erection of blast furnaces at various points in the Province: at Hamilton in 1895; at Deseronto in 1898; at Midland in 1899; at Sault Ste. Marie in 1904; and at Port Arthur in 1907. Strenuous efforts were made to use Ontario ores as far as possible and thus obtain the advantage of the liberal bounties offered; iron mining took on a new lease of life, and prospecting for iron ores became general.

In eastern Ontario old mines were re-opened, and for a time ore was shipped in small quantities. Unfortunately the quality of most of it was poor, and cobbing had to be resorted to, to rid it of sulphur and other deleterious ingredients, and bring it up to merchantable grade. As a result these mines have again, one by one, lapsed into idleness.

Iron Ore Produced and Utilized in Ontario, 1869–1916.

Calendar Year.	Iron ore produced in Ontario.	Iron Ore used in Ontario Blast Furnaces.			Ore used in Ontario blast furnaces. Per cent.
		Ontario ore.	Imported ore.	Total.	
	Tons.	Tons.	Tons.	Tons.	
1869 to 1895	567,276	....	....	....	....
1896	15,270	15,270	35,868	51,138	29·8
1897	2,770	2,770	34,722	37,492	7·4
1898	27,409	20,968	56,055	77,023	27·2
1899	16,911	24,494	85,542	110,036	22·2
1900	90,302	22,887	77,805	100,692	22·7
1901	273,538	109,109	85,401	194,510	56·1
1902	359,288	92,883	94,079	186,962	49·6
1903	208,154	48,092	103,137	151,229	31·8
1904	53,253	50,423	173,182	223,605	22·6
1905	211,597	61,960	383,459	445,419	13·9
1906	128,049	101,569	396,463	498,032	20·4
1907	205,295	120,156	388,727	508,883	23·6
1908	216,177	170,215	342,747	512,962	33·2
1909	263,777	220,307	543,544	763,851	28·8
1910	230,656	143,284	678,890	822,174	17·4
1911	175,631	67,631	848,814	916,445	7·3
1912	117,357	71,589	1,062,071	1,133,660	6·3
1913	195,937	132,708	1,095,561	1,228,269	10·8
1914	275,956	163,779	752,560	916,339	17·8
1915	394,054	293,305	623,094	916,399	32·0
1916	320,487	215,366	1,056,810	1,272,176	17·0
Total	4,349,144.				

In northwestern Ontario, the discovery, in 1899, of the deposit of brown hematite that later developed into the Helen mine, together with the fact that throughout this part of the Province there are widespread outcrops of banded jaspers, magnetites, and hematites, of the same geological formations as the Vermilion and Mesabi iron ranges in Minnesota, led to feverish activity in the search for iron ore. Very large sums of money were spent in looking for new deposits and in the exploration of the known ones. The net results of these efforts have been disappointing; we have, it is true, the Josephine mine (still undeveloped); Atikokan, with its high sulphur ores; the Magpie, Helen and other siderite bodies; and a variety of the lower grade, siliceous deposits of banded iron formation. But the only large body, both high grade and of good quality, yet discovered in Ontario, is that at the Helen mine.

Since 1899, owing principally to the output of the Helen, the iron ore production has averaged in the neighbourhood of 220,000 tons per annum,

and reached a maximum in 1915, when 394,054 tons were produced. This, however, is a long way short of the amount of ore used annually in the production of pig-iron, and the proportion of native ore, as compared with foreign ore, used in Ontario blast furnaces, is disappointingly small. The only furnace run entirely on Ontario ore, since the revival of iron smelting in 1896, was the Atikokan Iron Company's furnace at Port Arthur, which during its period of operation, from 1907 to 1911, used roasted Atikokan magnetite alone.

The imported ores used in Ontario all come from the United States, Lake Superior district.

With the rapidly approaching exhaustion of the hematite ore at the Helen mine, the maintenance of the present rate of iron ore production will depend on the possibility of profitably utilizing the known bodies of inferior ores, or the discovery of new bodies of high grade ores. The most promising of the more accessible portions of the Province have been pretty well gone over by the iron ore prospector, and the discovery of any large new ore bodies in them is more likely to be made by the underground exploration and diamond drilling of known occurrences, rather than by ordinary surface prospecting. There is, however, still a large part of the more inaccessible portions that is virtually unprospected, and promising areas, like the Animikie rocks at Sutton Mill lakes in the district of Patricia, may yet be found to contain valuable deposits of iron.

All the usual varieties of ore are to be found in Ontario; including hematite (brown, red, and specular), magnetite, siderite, and bog ore. In the past, by far the most productive class has been hematite—followed by magnetite. At the present time the bulk of the output is roasted siderite; the figures for 1916 being 210,522 short tons of roasted siderite (this includes some high sulphur ore from the Helen mine sent to be roasted with the Magpie ore), and 109,965 short tons of hematite.

Brown Ore.—Of the total production of hematite in Ontario, by far the greater part has been of the brown variety, from one mine in the Michipicoten district—the Helen. The output of this mine from its opening in 1900 to the end of 1916, has been 2,645,110 short tons: the largest output yet recorded from any iron mine in Canada. The ore, which consists of a mixture of hematite, with hydrous oxides of iron, largely göthite, is classed as a non-Bessemer, brown ore. Associated with it are large bodies of siderite and pyrite, from which it has probably been derived by oxidation. The oxidized ore is now nearly all worked out, and it is evident that the future of the mine will depend on whether profitable use can be made of the accompanying bodies of iron carbonate. Exploration of these, to obtain a fuller knowledge of their extent and quality, was carried on by the owners in 1913, 1914, and 1916,

Ore, similar in character to that at the Helen, occurs at a number of other points in the Michipicoten district; but the only other place where it has been found in workable quantity is at the Josephine mine. Here, some 850,000 tons of ore, a large part of which is said to be of Bessemer grade, averaging 59 per cent in iron, are said by the owners to have been proved up by diamond drilling. The deposit, however, has not yet been developed to the producing stage, though preparations for doing so were under way until interrupted by the outbreak of the European war.

Limonite, or brown ore, is also found in the Timiskaming district, on the Mattagami and Opasatika rivers, where it has been formed, apparently, by the oxidation of iron carbonate occurring in the Devonian limestones of the region. The ore is very variable in its composition, and on the whole, low grade. Little is known of the extent of the deposits, which are some distance from transportation.

Hematite.—In the vicinity of Loon lake, about 25 miles east of Port Arthur, red hematite is found in the Animikie rocks of the district. The deposits occur in certain beds in the formation, and appear to have considerable areal extent, but interlayered siliceous material renders them too low grade to be merchantable as mined. From the property of the Dominion Bessemer Ore Company there was shipped, in 1909, a small quantity of hand-sorted ore in two grades, No. 1 running 52 per cent iron, and No. 2, 40 per cent. Since 1909, all operations have ceased.

Red, and specular hematites of good grades are found in small quantities in the vicinity of Sault Ste. Marie; notably in the townships of Deroche, Aberdeen, and Aberdeen Additional. Between 1874 and 1878, small quantities of specular ore were shipped from the Stobie mine in Aberdeen township. From the Williams and Breitung mines in Deroche township, a few small shipments of specular ore of good grade were made to the Sault Ste. Marie smelter in 1905. All the deposits appear, however, to be of very limited extent, and no ore bodies large enough to be of commercial importance have so far been exposed.

Other localities in northwestern Ontario where hematite has been found are: Hunter's island, Steeprock lake, Bending lake, Lac Seul, Sutton Mill lakes, the Mattawin iron range, Gunflint lake, Dog lake, Black Sturgeon lake, Round lake, east of Lake Nipigon, Batchewana river and Groundhog river. The hematite in all these occurrences is found intimately associated with silica, and usually, magnetite in the banded iron formation; in none is the iron sufficiently concentrated to constitute commercial ore.

On a number of them, such as those at Hunter's island, Steeprock lake, Bending lake, Gunflint lake, and on a part of the Mattawin iron range near Shabaqua, a certain amount of diamond drilling has been done in unsuccessful attempts to locate ore bodies.

On the Central and Southern iron ranges east of Lake Nipigon, also, a large amount of exploratory work, including some diamond drilling, has been done. On the Central range, banded siliceous hematite carrying in places between 40 and 50 per cent in iron has been found, and on the Southern range considerable areas of banded silica, hematite and magnetite carrying from 30 to 40 per cent, but no bodies of merchantable grade.

On the Algoma Eastern Railway claims at Groundhog river, considerable areas of banded magnetite, hematite and jasper running about 35 per cent in iron, have been explored by trenching.

A number of experimental tests have been made with this siliceous hematite-magnetite mixture of the iron formation in attempts to devise a commercial process for its concentration. None of them have been successful, however, and considering the physical characteristics of the material, the outlook for a successful solution of the problem is not bright.

In southeastern Ontario, from a number of properties, chief among which are the Wallbridge, Dalhousie, and McNab, hematite has been produced in the past to the total extent of probably 150,000 tons. The ores are said to have been of good quality, but little information about the individual mines is available.

The deposits were all small; some of them the upper oxidized portions of pyrites beds. There has been no production from any of them for some years, nor is there likely to be much in the future.

Magnetite.—Magnetite is of more frequent occurrence in the Province than any of the other classes of ore, and next to hematite, has been economically the most important. The total production of magnetite in the Province, to the end of 1916, would probably be in the neighbourhood of 1,175,000 tons.

Important occurrences found in western Ontario are those in the Atikokan "iron range," a belt of green schists with interbedded lenses of magnetite and pyrrhotite that outcrops at intervals for a distance of about 16 miles along the Atikokan river. On that part of the range west of Sabawe lake, most of the deposits contain so much sulphur in the form of pyrrhotite and pyrite that their value as iron ores is very doubtful. On the eastern end of the range, about a mile east of Sabawe lake, large bodies of magnetite have been opened up at Atikokan mine, the property of the Atikokan Iron Company of Port Arthur. Between 1907 and 1911 some 90,608 tons of magnetite averaging 60 per cent iron, 0·11 per cent phosphorus, and 2·01 per cent sulphur, were shipped to the blast furnace in Port Arthur, and after roasting to remove the sulphur, smelted for the production of foundry pig-iron. Development work at the mine was carried on until 1913, but no ore has been shipped since 1911 when the Company's blast furnace closed down.

The total amount of ore proved by exploration and development on the Atikokan range is fairly large. The amount of intermixed rock found in many parts of the deposits, however, is sufficient to adversely affect the amount that could be mined economically. Much of the ore, also, is so high in sulphur as to make its profitable utilization by present metallurgical methods doubtful. It is difficult, therefore, to make any definite estimate of the amount of ore *commercially* available.

With the exception of the Atikokan range, nearly all the magnetite occurrences known in northern and western Ontario are outcrops of banded iron formation. Speaking generally, this consists of chert, jasper or other closely related siliceous material interbanded with magnetite and hematite, and, to a smaller extent, with iron carbonates and pyrite. In some cases it may be a lean siliceous magnetite, showing banding only obscurely, and carrying up to between 40 and 50 per cent of iron—though as a rule the iron content is considerably less than this. Or it may consist of narrow bands of magnetite, or hematite, or a mixture of both, alternating in distinct layers with chert and jasper. The total length of the known beds in the Province must reach into the hundreds of miles. It is seldom that the iron content will average up to 35 per cent over any considerable area.

The occurrences on Hunter's island and in the Gunflint-Whitefish lakes area, like those at Loon lake and Sutton Mill lakes, are found in Animikie rocks. The rest are all believed to occur in rocks of Keewatin age.

The similarity to iron-bearing formations found on the Minnesota iron ranges has caused great expectations to be entertained of the possibilities of that found in Ontario, and it is this commercially non-available lean iron formation, rather than ore, that has provided the basis for the reports, sometimes seen in print, of hundreds of millions of tons of ore of the United States Lake Superior type still lying undeveloped in Ontario. Even under the most favourable conditions only a small fraction of the iron in these formations is likely to be in ore of commercial grade. In Ontario, much money has been spent in exploring them, but so far, only at the Helen and Josephine mines in the Michipicoten district, have secondary concentrations of the iron to high grade ore bodies of commercial size been found associated with them.

Among the more extensive and better explored of the iron formation areas are: Hunter's island; Bending lake; the Mattawin iron range; the Gunflint-Whitefish lakes area; Loon lake area; Lake Savant; the Onaman iron ranges; the Nipigon iron ranges; the Michipicoten iron ranges; Goulais river; Woman river; Groundhog river; Burwash lake; Shining Tree lake area; Wanapitei lake area; Lake Timagami; and the Moose Mountain district.

At the Moose Mountain mine, much time and money has been spent in an unsuccessful attempt to produce a high grade commercial product from

the lean siliceous magnetite of the iron formation. The ore as found at this mine is of two types: the first is a more or less massive magnetite, free from banding, and possibly represents a portion of the original iron formation that was subsequently enriched by iron-bearing solutions; the second is a fine-grained banded siliceous magnetite, somewhat higher in iron than the typical Keewatin iron formation, since it carries about 37 per cent iron and 45 per cent silica. From the ore of the first type it was found possible to produce a marketable concentrate, carrying about 55 per cent in iron, by magnetic cobbing, and a considerable quantity was produced in this way. Since, however, the quantity of crude ore of this type available was very limited, it became evident that, if the mine was to continue in operation, means must be found for utilizing the lower grade banded material of the second type. Experimental tests showed that by very fine grinding, followed by magnetic concentration on Gröndal separators, a good separation of magnetite from gangue could be effected, and that by subsequently briquetting and sintering the resultant concentrate, a product of Bessemer grade, carrying 65·6 per cent of iron, and excellently adapted for blast furnace use could be obtained—2·1 tons of crude ore being required to produce a ton of concentrates.

A mill to treat the low grade ore along these lines was accordingly built in 1912. From the start, however, practical difficulties were met with in its operation, and in 1915, after three years experimenting and the production of some 10,159 gross tons of finished briquettes, it was finally closed, the process having proved unsuccessful commercially.

In southeastern Ontario magnetite has been mined in the past from a number of deposits scattered through the counties of Haliburton, Peterborough, Hastings, Renfrew, Frontenac, Lanark, and Leeds. The total production from these, as nearly as can be estimated from the information now available, has been between 700,000 and 750,000 tons. The chief producers were, in the order of their production, Blairton, Wilbur, Bessemer, Coe Hill, Glendower, Black Bay, Radnor, and the Matthews and Chaffey (titaniferous) mines. All of them are now idle. None of the individual deposits are very large. The deepest any of them has been worked is about 350 feet; in most the workings are much shallower. The known dimensions of the deposits do not indicate that there is in the aggregate more than a very few millions of tons of commercial grade available.

The ores vary from lean magnetite gneiss with bands and ribs of magnetite to deposits of nearly pure magnetite. The better grades will average 50 to 55 per cent in iron, but considerable cobbing would have to be done to keep any large quantity up to this standard. The sulphur content, while variable, is usually too high to allow the ore to be used in the blast furnace without some preliminary treatment for its removal.

Tests made on ores from a number of the mines have shown that many of them are well adapted for magnetic concentration. By crushing, concentrating on magnetic separators, and sintering the concentrates on a Dwight-Lloyd machine, a high grade, porous product, low in sulphur, and excellently adapted to blast furnace use, can be obtained. While it may be that none of the individual mines have ore reserves large enough to warrant the erection of a plant of sufficient capacity to ensure the economical working of such a process, it should be possible to make such a project feasible, by combining the output of a number of properties, and erecting a concentrating plant for its treatment at a point centrally located with respect to the mines.

Titaniferous magnetites are found at Seine Bay; Haystack mountain; Nemegos; Mountain lake; near Gooderham, in Haliburton county; at the Orton mine in Hastings county; and at the Matthews and Chaffey mines. Previous to 1871, some 20,500 tons of this material were shipped from the Matthews and Chaffey mines to United States blast furnaces. As titaniferous magnetites are not now in favour with blast furnace men they have no market as iron ores at present.

At many points along the shores of the Great Lakes, such as Peninsula harbour on Lake Superior, concentrations of magnetite sands are found. Some accumulations of this kind on the north shore of Lake Erie were smelted in a small furnace at Normandale about 100 years ago. They are not, however, of economic importance.

Siderite.—Since 1913, roasted siderite from the Magpie mine has appeared in the list of ores produced in Ontario, and this material now constitutes the bulk of the output of the Province.

Shipments of roasted siderite from the Magpie mine have been made, as follows:—

1913	22,327	short tons.
1914	109,838	"
1915	132,906	"
1916[1]	210,522	"

The raw ore is a dense, fine-grained siderite, partly altered to magnetite. It carries about 35 per cent of iron, and an objectionable amount of sulphur in the form of pyrites. This is roasted in rotary kilns to a product running about 51 per cent in iron, and 0·25 per cent sulphur. The roasted siderite ranks as an Old Range Bessemer ore and is practically self fluxing.

The Magpie ore-body is about 50 feet wide. In 1915 a working shaft had been sunk on it to a depth of 337 feet, and it had been developed for a length of about 1,500 feet. West of the shaft the ore-body is cut by a trap dike about 100 feet wide. Unlike the deposits of oxidized ore in this region,

[1]Partly high sulphur hematite from the Helen mine roasted with the Magpie ore.

the Magpie deposit shows no trace of the typical banded iron formation. Its walls are the sericite and chlorite schists of the Keewatin, and its appearance points to its origin as a vein.

Development work has proved up large reserves of ore of the same grade as that now being used, together with some of inferior quality.

Besides the large bodies of siderite known to exist at the Magpie and Helen mines, it occurs also in the following localities in the Michipicoten district—at some of them in considerable quantity: the Morrison prospect (near Goudreau station); on the Johnston locations; at Brooks lake; at the Ruth mine; at the Josephine mine; and on the Bartlett property. Any process, therefore, that will make it possible to use profitably ore of this class is of more than usual importance. The results obtained at the Magpie mine are of special interest in this connexion.

Siderite is also found on the Mattagami and Opasatika rivers, in the Timiskaming district, where it occurs associated with limonite in the Devonian limestone of the region. Some of it is of exceptionally high grade, but the extent of the deposits is unknown, and they are at present a long way from transportation.

Large deposits of lower grade are also reported to occur at Steeprock lake, in the Rainy River district, and in the Animikie rocks, in the vicinity of Port Arthur.

Bog Ore.—Deposits of bog ore are known to occur at a number of points in both the older and newer sections of the Province. As far back as 1813, small quantities were smelted at Normandale, in Norfolk county. More recently, a small quantity from Oxford county was smelted in the Hamilton furnace. In northwestern Ontario it is found in a number of places, as in the vicinity of Niblock station, on the Canadian Pacific railway. So far as known, however, none of the deposits are large enough to be of economic interest.

QUEBEC.

Iron ore was first mined and smelted in the Province of Quebec early in the eighteenth century, and from that time until 1883, the industry was carried on almost continuously at Three Rivers in the St. Maurice district. Other furnaces using local ore were operated at Radnor Forges and at Drummondville, the last to shut down being the Drummondville furnace in 1911. The ores used were bog ores, with charcoal for fuel. The output of all the furnaces was small, and the industry derived its chief importance from the superior quality of the pig-iron made.

Furnaces have also been built at various times and places in attempts to smelt some of the other classes of ore found in the Province, but all were short lived, and none of them achieved commercial success.

The output of iron ore, never very large, has latterly occupied a very subordinate place in the mineral production of Quebec; by years it is as follows:—

	Short tons.		Short tons.
1886		1901	15,489
1887	13,404	1902	18,524
1888	10,710	1903	12,035
1889	14,533	1904	16,152
1890	22,305	1905	12,681
1891	14,380	1906	9,933
1892	22,690	1907	12,748
1893	22,076	1908	10,103
1894	19,492	1909	4,150
1895	17,783	1910	4,503
1896	17,630	1911	3,616
1897	22,436	1912	1,185
1898	17,873	1913	5,102
1899	19,420	1914	nil
1900	19,000	1915	nil
		1916	nil

Types of ore found include: magnetite (titaniferous and non-titaniferous), ilmenites, bog ore, and hematite.

Magnetite.—Non-titaniferous magnetites are found in the counties of Argenteuil, Compton, Megantic, Ottawa, and Pontiac. None of the deposits are of any very great extent. The only ones known to be large enough to be of any interest are those at the Bristol mine in Pontiac county, and the Forsyth mine in Ottawa county.

The ore in both these mines is predominantly magnetite, with a little accompanying hematite. That at the Bristol mine is so high in sulphur that it would require roasting. The best grade of ore, in both, carries between 50 and 60 per cent in iron, but the quantity of this grade available appears to be small, and to work either property on a commercial scale it would likely be necessary to mine poorer material and concentrate it to merchantable grade.

Titaniferous magnetites are found in the counties of Beauce, Saguenay St. Maurice, and Terrebonne, and in the Lake St. John district. They occur as basic segregations in anorthosite and gabbro masses and are, for the most part, individually quite small. The largest of those known are the Cran de Fer falls deposit, in Saguenay county, and that at the St. Charles mine, in the Lake St. John area. At Cran de Fer falls the ore contains 50 per cent or over in iron, and 12 to 15 per cent titanium, and there are believed to be at least 300,000 or 400,000 tons available. At the St. Charles mine, it is estimated that there are at least 1,000,000, and possibly 5,000,000

tons in the deposit, which shows in the outcrops 50 per cent iron, and 10 per cent titanium. On account of their titanium content, magnetites of this type would not, at present, be marketable as iron ores. Some activity has recently been manifested in investigating their possibilities, however, and it is possible that in the near future they may become of commercial importance.

Closely related to the titaniferous magnetites, and occurring like them as basic segregations in anorthosite, are the *ilmenites* found in Charlevoix and Terrebonne counties. These deposits carry from 40 to 45 per cent iron, and 21 to 25 per cent titanium. They are not at all, or only feebly, magnetic. They have been mined to some extent, and the ore shipped to be used in the electric furnace for the production of titanium alloys.

Hematite.—Small pockets and narrow veins of excellent hematite were mined at the Haycock mine in Ottawa county in 1873. The deposits were very small, and the enterprise was soon abandoned.

Small occurrences are reported at various other points in the Province, but are all too small and unpromising to be of interest.

Bog Ores.—Bog ores are of widespread occurrence, but are now chiefly of historic interest. Beds on the north shore of the St. Lawrence in the vicinity of Three Rivers, were worked for over 150 years, and were the source of supply for the small charcoal furnaces formerly operated in that locality. On the south side of the St. Lawrence, the Drummondville furnace was run on bog ores obtained in that neighbourhood. Some of the deposits are worked out, and those that remain, while numerous, are not thought to be extensive enough to furnish much ore.

Magnetic Sands.—At a number of places along the north shore of the Gulf of St. Lawrence, accumulations of black sand (magnetite and ilmenite) are found, and attention has been attracted to them as a possible source of iron. Within recent years their extent and suitability for this purpose have been investigated by different parties. So far there has been no attempt to follow up these preliminary investigations by commercial operations.

From the point of view of possible source of future iron ore supplies, the District of Ungava, which includes the northern portion of the Province of Quebec, deserves special attention. In this District, large areas of sedimentary rocks including low grade bedded deposits of magnetite, hematite, and jasper are known to occur—the formation showing a striking resemblance to the Animikie rocks of the Lake Superior iron ranges. Situated as they are, in a wilderness far from transportation, and difficult of access, they remain as yet unprospected, though their promising character is such as to justify the hope that deposits of iron of economic value may be found in them.

NEW BRUNSWICK.

New Brunswick, like all the other provinces in Eastern Canada, except Prince Edward Island, had, in early days, its small local iron industry based on local ores.

Between 1848 and 1884, about 70,000 tons of hematite, obtained from deposits in the neighbourhood, were smelted in a small furnace near Woodstock, in Carleton county. The deposits were very shallow and the iron content of the ore low.

Some limonite from small deposits at Maugerville, a few miles southeast of Fredericton, was also smelted in the same furnace.

As a producer of iron ores, however, the Province has never been prolific. From 1886 to 1909, no output is recorded; from 1910 to 1916, shipments to the extent of 202,850 tons were made, all from one mine.

The only known deposits that have any economic interest are those found near Austin Brook, in Gloucester county, about 23 miles southwest of the town of Bathurst, and known as the Bathurst mines. They consist of fine-grained, siliceous magnetite with which is intermixed some hematite. Interbanded with the magnetite and hematite there are more or less chlorite and hornblende schists, and quartz. The iron content varies in different layers from 35 to 59 per cent, the average being from 43 to 47 per cent in different parts of the ore bodies; phosphorus runs about 0·8 per cent.

Genetically, the deposits are thought to be a partial replacement of schistose quartz porphyry; the iron-bearing solutions having possibly been derived from igneous intrusives found in the vicinity of the ore-bodies.

The ore as mined having been found too low in iron for profitable shipment, a concentrator was erected in 1911, to bring it up to merchantable grade by a process of crushing, screening, and jigging. The plant was started in July, 1912, and since that time shipments have been of concentrates, running 48 to 49 per cent in iron. In 1913, all operations ceased.

The concentrating process adopted did not prove satisfactory; the average improvement in iron content being only about 2 per cent. It is thought, however, that ore of merchantable grade can be produced by a system of selective mining without concentration.

An estimate of the ore reserves, based on the evidence afforded by magnetometric surveys and diamond drill holes, is placed at 18,600,000 tons to a depth of 500 feet.

On the Ellis iron claim, about 9 miles north of the town of Bathurst, a deposit of interbanded magnetite and garnet, from 4 to 14 feet wide, has been traced for a distance of about 900 feet. Average samples taken across the deposit show 45 to 48 per cent of iron.

NOVA SCOTIA.

Nova Scotia, though the seat of large iron and steel industries at the two Sydneys and New Glasgow, is not at the present time a producer of iron ore. Nevertheless, deposits of iron ore of various kinds are numerous and widely distributed through the Province; with the exception of the Pre-Cambrian gold-bearing series occupying the southern part of the mainland all of the larger divisions of sedimentary and accompanying igneous rocks in Nova Scotia show iron ore minerals in such quantities as to have attracted at least a passing attention from mining men. If we were to judge of the possibilities of the Province for the production of iron ore by some of the more optimistic of the earlier reports and papers descriptive of its resources, we would be led to look for the growth of a large iron mining industry as the country developed. But the better the deposits became known, the more they shrunk in volume and declined in quality; and we must attribute these earlier claims to the undeveloped state of the country and the natural optimism of early explorers in a comparatively unknown region.

While next to Ontario, Nova Scotia has to its credit the largest aggregate output of iron ore of any Province in the Dominion, the total tonnage from the earliest days to the present would not last a large modern plant very many years (in 1915, 840,394 tons of Newfoundland ore were used in Nova Scotian blast furnaces). Latterly, with the exhaustion of the workable deposits of better grade ore, production has declined until now it has reached the vanishing point. The extensive development of the Wabana iron ore field in Newfoundland, and the ease and cheapness with which Nova Scotian furnaces can secure a supply of suitable ore from that source, have also operated to decrease interest in the development of local supplies.

The production of iron ore in Nova Scotia since 1886 is as follows:—

	Short tons.		Short tons.
1886	44,338	1901	18,619
1887	43,532	1902	16,172
1888	42,611	1903	40,335
1889	54,161	1904	61,293
1890	49,206	1905	84,952
1891	53,649	1906	97,820
1892	78,258	1907	89,839
1893	102,201	1908	11,802
1894	89,379	1909	
1895	83,792	1910	18,134
1896	58,810	1911	22
1897	23,400	1912	30,857
1898	19,079	1913	20,436
1899	28,000	1914	
1900	18,940	1915	
		1916	

From the point of view of past production, the most important class of ore has been brown ore, or limonite. Such occurs notably in the contact deposits of Pictou, Colchester, and Hants counties, and as an alteration product from carbonates in an extensive series of fissures in the Londonderry field. Massive red hematite, of the Clinton type, low in iron and sulphur, but high in phosphorous and silica, is found typically developed at Torbrook; extensive beds of lower grade occur in Antigonish and Pictou counties. Magnetite is not met with in promising amounts except as a metamorphic product from hematite in the Torbrook-Nictaux and Clementsport fields. Siderite is found to some extent in Pictou and Colchester counties and at Londonderry, but has little importance.

At present the most important and promising iron ore field in the Province is the Torbrook-Nictaux basin in Annapolis county. The ores are hematite of the Clinton type and bedded magnetite metamorphosed from it, occurring in upper Silurian limestones and siliceous slates. Two workable beds are known to exist—the Leckie bed and the Shell bed. The ore of the Leckie bed is hematite for the most part, though magnetic in places; usually massive, but sometimes oolitic. The ore from the Shell bed exhibits two features not often found together; it is fossiliferous, and at the same time, highly magnetic.

Three mines have been operated in the district. The first was the Leckie mine opened in the bed of the same name, at the eastern end of the productive area. After reducing some 193,807 tons of ore, it was abandoned as worked out, the ore having been lost at a depth of somewhat more than 330 feet by the pinching in of the walls. The Martin mine has been opened up on the same bed as the Leckie, but at some considerable distance from it and near the western end of the field. The shaft at this mine has reached a depth of 500 feet, and cross-cuts connect it with the Shell vein. The total output of ore has been 102,100 tons, and when the mine shut down in 1913, there were in the stopes on the Leckie mine, above the 500 foot level, approximately 115,000 tons of ore, while the reserves developed on the Shell vein are placed at 250,000 tons. The Wheelock mine is situated about 2,000 feet northeast of the Martin mine, and is sunk on the Shell bed, on which it is the chief producer. The shaft is down only about 180 feet, but the bed is known by drilling to 382 feet.

Since the crude ore as mined from the two beds is too low in iron to be saleable, a concentrating plant to bring it up to merchantable grade was erected at Nictaux in 1911. The concentrates, shipped for export, ran 50 to 52 per cent iron, 13 per cent silica, 1·32 per cent phosphorus, and about 0·015 per cent sulphur. In 1913, operations ceased, and mine and plant have since been idle.

Experiments in magnetic concentration of the Torbrook ores have been made, but proved unsatisfactory on account of the large percentage of hematite contained in them.

In the Clementsport district, in the western part of Annapolis county, beds of magnetite similar in origin to the Shell bed at Torbrook are found. Little is shown of their extent or quality, though three of the occurrences have been worked in a small way in the past. At least two of the beds may be continuous for a long distance, and the field is regarded as a promising one for exploration.

The hematite beds of the Clinton type found in the Ordovician rocks in Antigonish and Pictou counties are of considerable extent, and would be very valuable if of good grade and quality. They are too low in iron and too siliceous to be workable under present conditions. Somewhat similar beds in the Cambrian rocks of the Mira valley in Cape Breton show some excellent ore, but the deposits are so narrow and intermittent that they have little value.

The mixed limonite-hematite-ankerite ores found in the Devonian slates and quartzites in the vicinity of Londonderry were for many years the chief source of supply for Nova Scotian iron furnaces. They are of some historic interest, also, on account of the fact that it was at Acadia mines in 1874 or 1875 that Dr. Siemens made his first commercial experiment in the direct conversion of iron into steel.

The ores lie in a long and well marked zone of fissuring in Devonian slates and quartzites near the contact with the various acid intrusives forming the central portion of the Cobequid hills. The fissured zone is occupied by a complicated system of veins of ankerite, siderite, etc., which has been oxidized in part to limonite and hematite. The oxides, which form the productive ore, are relatively superficial, rarely being found far below present drainage. They are especially low in sulphur and phosphorus, and were exceptionally pure in the upper working before the zone of carbonates was reached.

The total yield of brown ore alone from this field since 1849 is over 2,000,000 tons. No mining has been done for some years now, and the ore of commercial grade is believed to be practically worked out.

In Pictou, Hants, and Colchester counties, deposits of brown hematite are found forming irregular lenses and pockets at or near the contact of lower Carboniferous rocks with the underlying Pre-Cambrian, Silurian and Devonian formations. They are apparently in part replacements of limestone, in part fissure fillings. Similar deposits of small extent are also found in Cape Breton. Those at Brookfield in Colchester county and at a number of places in Pictou county have been mined in the past. The largest output recorded from any one deposit, however, is less than 50,000 tons; from most of them much less. Those that are known to be workable are now worked out, and while others will probably be found, it is not likely that they will add appreciably to the iron ore resources of the Province.

Small narrow veins and stringers of rich specular hematite are found at a number of places through the Province, especially in Guysborough county, and much attention has been attracted to them on account of the richness of the ore. None are known to be of workable size, and from the nature of their occurrence, it is not likely that large bodies of this kind will be found.

Bog ores and clay ironstone are of frequent occurrence, but only in limited quantity.

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In addition to those referred to in the description of individual occurrences in the body of the report, the following list contains titles of a number of articles and reports dealing with Canadian iron ores.

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VOL. I

DESCRIPTIONS OF PRINCIPAL IRON ORE MINES.

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IRON ORE OCCURRENCES IN CANADA.

VOL. I

DESCRIPTIONS OF PRINCIPAL IRON ORE MINES.

BRITISH COLUMBIA.

Texada Island Iron Mine.

Owners: Puget Sound Iron Company,
San Francisco, Cal., U.S.A.

The Puget Sound Iron Company acquired its Texada Island iron properties in 1873. The mines were operated intermittently between 1883 and 1907, during which time shipments of probably about 50,000 tons were made to the blast furnace at Irondale, Washington, U.S.A.

The iron ore deposits—the chief of which are known as the Prescott, Paxton, and Lake mines—are situated on the west coast of the island, about 3 miles north of Gillies bay. The ore is magnetite, and occurs in lenses of varying size, in an area 1½ miles long and one-half mile wide.

The ore-bodies are all exceptionally well situated for cheap mining and transportation. The distance of the main deposits from the coast range from a few hundred feet to a mile, with elevation above sea-level from 300 to 800 feet. The ore would be won by quarry, tunnel, and shaft development, and transported by surface trams to the loading pier.

The Prescott Mine and Vicinity.

The outcrops occur on a steep hillside, near the western end of the iron range, at elevations of from 300 to 580 feet above sea-level. The ore-bodies have formed along a contact between quartz diorite and limestone.

"They are enclosed in a roughly lenticular-shaped area, about 600 feet in length with a maximum width of 380 feet, in which are a few diorite and limestone cores.

"The development work consists of three large surface cuts on the principal magnetite lenses, and a shaft 150 feet deep sunk at the southerly tip of the mineralized areas. From the foot of the shaft a tunnel was driven in a northerly direction, through diorite, towards the main ore-body, which it reached at a distance of 215 feet. It was continued into the ore-body for a distance of 65 feet, and was subsequently extended southwards to meet the sloping surface. A second and shorter tunnel has been driven into the magnetite 250 feet higher up.

"As far as can be learned, the following shipments have been made from this mine:—

"Prior to 1884, ore was shipped, but the amount cannot be ascertained.

"Between 1884 and 1888 some	5,500	tons were shipped.
In 1889	1,600	" " "
" 1901	2,500	" " "
" 1902	6,290	" " "
" 1903	2,290	" " "
	18,180	

"The Annual Reports of the British Columbia Minister of Mines record no shipments since 1903.

"The main magnetite mass is roughly crescentic in outline, has a length of 300 feet, with an average width of about 80 feet; and has been proven by a tunnel, to extend downwards for a distance of 430 feet below the highest outcrop. The dimensions in depth are not known, as the tunnel ends in ore after penetrating it for a distance of 75 feet.

"In addition to the main mass, several smaller lenses occur in the same altered area, two of which have been opened up by surface cuts."

The largest of these outcrops is a rounded mass about 75 feet in diameter occurring in the limestone. The third ore-body, as developed, is 100 feet long by 20 feet wide, and occurs in quartz diorite.

The magnetite is coarsely crystalline and is rarely free from impurities. Marcasite, pyrite, chalcopyrite, garnet, hornblende, epidote, quartz, and calcite are the associated minerals. A rough sample on the main ore face gave:—

Iron	64·30 per cent.
Copper	0·14 "
Sulphur	0·303 "

The light-coloured areas, composed mainly of quartz and calcite, were excluded from this sample.

"West of the Prescott mine, a number of magnetite lenses of moderate sizes occur along the diorite-lime, and farther on along the porphyrite-lime contacts, the larger having a length of 90 feet and a width of 20 feet. Lenses have also formed at a few points along the small outlying diorite stocks and dikes. A lens 57 feet long and 20 feet wide occurs at one point forming the continuation of a diorite dike. The magnetite in this lens is remarkably free from both sulphides and non-metallic impurities. It contains a small percentage of manganese. It yielded on assay, iron 68·20 per cent, copper none, sulphur trace, manganese 0·08 per cent.

"North of the Prescott mine three large and several small lenses of magnetite occur in one of the limestone bays. The most westerly and largest of these

has formed entirely in limestone. It has a length of 250 feet and an average width of about 50 feet. The second lens has a length of 160 feet, a width of 40 feet, and has formed along the contact. The third lens has developed partly in diorite and partly in limestone, and has a length of 200 feet and a width of about 70 feet. The ore, judging from the surface exposure, is of superior quality, and the percentage of sulphides present is very small.

"Southwest of the Prescott a mineralized area in the quartz-diorite about 75 feet across, is exposed in a cut on the tramway from the mine to the coast. The area contains a narrow lens of magnetite, but consists mainly of epidote, garnet and small bunches of magnetite. The percentage of sulphides present, mostly iron pyrites, is high."

The Paxton Mine and Vicinity.

"The Paxton ore-body situated at the eastern boundary of the quartz-diorite stock, about 3,500 feet east of the Prescott mine, ranks next to the latter ore-body in size. It has a length of 290 feet, a maximum width of 200 feet, and an average width of about 150 feet. It has developed entirely in the quartz-diorite near its contact with porphyrite.

"The southern part of the ore-body outcrops on a steep slope about 60 feet in height, the lower part of which is diorite, and the upper part magnetite. Two short open-cuts about 80 feet apart through the diorite, expose the diorite-magnetite contact. A tunnel 40 feet in length has been driven from the end of the most easterly of the cuts through the solid magnetite. The attitude of the magnetite lens is nearly vertical."

The ore is coarse-grained and contains a larger percentage of sulphides, mostly iron pyrites, than usual. A sample taken along the tunnel yielded:—

Iron	59·40	per cent.
Copper	0·30	"
Sulphur	1·07	"

To the north of the Paxton there are several lenses of magnetite of good quality exceeding 50 feet in length. Farther north along the lime diorite contact there are several small magnetite lenses, two of which are each about 60 feet long. East of the Paxton there is a rounded mass of magnetite in the limestone along with several smaller lenses.

The Lake Mine and Vicinity.

"An important body of magnetite occurs at the Lake mine, situated near the eastern known limit of the iron range, about 1,300 feet east of the Paxton mine. A magnetite mass measuring 180 feet in length, with an average width of 130 feet, has formed here in the porphyrite at the bottom of an angular limestone bay. The magnetite is bordered on three sides by porphyrite, and has apparently developed mostly in that rock. Lime-

stone occurs on the north, but is separated from the magnetite mass by an irregular area consisting mostly of garnet and epidote. Pyrite, pyrrhotite and magnetite in scattered grains and bunches are also present, and the latter in two places forms small lenses.

The magnetite in this ore-body is finer-grained than in the other large masses, and is freer from iron and copper sulphides."

A rough general sample from the magnetite cliff yielded:—

Iron	57·50 per cent.
Sulphur	0·046 „
Copper	Trace.

A buried lens of magnetite was encountered in the development of a copper deposit 250 feet to the northeast of the main body. A line of narrow lenses about 1,000 feet in length occurs south of the Lake mine in the porphyrite. The most northerly lens is 220 feet long, with a width varying from 10 to 20 feet. A sample yielded:—

Iron	69·40 per cent.
Sulphur	0·01 „
Copper	None.

The other lenses measure respectively 50 and 84 feet in length, and 10 and 20 feet wide.

The ore in all these lenses is fine-grained and remarkably pure.

Ore Reserves.—The total quantity of ore in the various outcrops is difficult to estimate as practically no development has been done below the surface except in the Prescott mine.

"For the purpose of making a rough estimate, it is assumed that the lenses extend downwards for a distance equal to their exposed surface length. The Prescott ore-body with a surface length of 300 feet has been proven to extend downwards for a distance of 430 feet, and at the low level is still strong and must descend considerably farther.

"The tonnage in the main Prescott ore-body above the lower tunnel is estimated at 1,366,400 tons. The three large lenses in the limestones northeastward from the Prescott, assuming that they persist to a depth equal to their surface length, would yield 993,600 tons. The Paxton ore-body should yield 1,607,200 tons, and the Lake ore-body 504,000 tons. The total tonnage in the six ore-bodies, estimated on the basis adopted, amounts to *4,521,200 tons.* (R. G. McConnell).

"No account is taken in this estimate of the numerous small lenses, from 20 to 100 feet or more in length, occurring along the range. Some of these are surrounded by large areas of intense alteration and mineralization, and the concealed portions may be much larger than the small outcrops appear to indicate.

"It is also unlikely that the lenses cut by the present surface represent the lowest tier formed. It is more probable that they are followed in depth along the contacts by other lenses, and the tonnage given above may be multiplied several times before the iron resources of the district are exhausted."

General Character of Ore.—"The magnetite lenses vary greatly in the amount of impurities they contain, more especially in regard to the sulphides. The rocks in which the lenses formed appear to have had some influence on the character of the ore, as those in the porphyrite are the purest on the whole, and those in the diorite the most impure. The lenses formed in the limestone are variable, some being nearly free from sulphides while others contain large percentages.

"The following assays of the three principal lenses were made in the laboratory of the Mines Branch from samples collected by Mr. E. Lindeman:—

	Prescott Ore-body. Lower tunnel.	Paxton Ore-body. 45-ft tunnel.	Lake Ore-body. Average of ore.
Silica	4·37	4·47	8·33
Iron	63·27	64·48	59·57
Alumina	1·18	0·66	1·71
Lime	2·58	1·32	3·82
Magnesia	1·05	1·13	1·05
Copper	0·09	0·22	0·08
Sulphur	0·347	1·866	0·137
Phosphorus	0·007	0·003	0·032

"These assays are probably fairly representative of the general run of the ore in the large masses. The phosphorus content in these and in numerous other recorded assays is low, usually well below the Bessemer limit. The copper content is also small as a rule, but in limited portions of the Prescott ore-body, and possibly in other lenses the amount present rises to over one per cent.

"Sulphur contained in the iron sulphides, pyrite, marcasite and pyrrhotite, and the copper sulphide, chalcopyrite, is the principal deleterious impurity. The Paxton ore-body is impregnated throughout with sulphides in grains and small aggregates. In the Prescott ore-body the distribution is more irregular, some areas carrying considerable percentages, while others are nearly free. The Lake mine ore-body is exceptionally free from sulphides except along its northern border.

"The small lenses vary from nearly pure magnetite to masses made up largely of sulphides. A sample from the line of lenses south of the Lake mine, assayed over 69 per cent iron, with no copper and only 0·001 per cent

sulphur. A sample from a moderate sized lens west of the Prescott mine proved almost equally pure. It contained 68·20 per cent iron, with no copper and only a trace of sulphur."

The comparatively high percentage of sulphur in the Paxton ore-body and in portions of the Prescott will necessitate special treatment of the ore to make it fit for blast furnace use. The percentage in the Lake ore-body, in portions of the Prescott, and in a number of the smaller lenses is low, and the ore from these can possibly be marketed as mined.

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The Glen Iron Mine.

Agent: S. C. Burton, Kamloops, B.C.

This property is situated at Cherry bluff on the south side of Kamloops lake, 13 miles west of Kamloops, and adjoining the Canadian Pacific railway.

It consists of 165 acres held under Dominion Crown grant, giving the surface and all iron deposits, also two mineral claims containing about 30 acres located under provincial laws adjoining the above, the whole having a frontage of about three-quarters of a mile on the Canadian Pacific railway. In addition there are two full-sized mineral claims, each 1500 by 1500 feet, located chiefly on the Crown granted land, but each covering a strip about 180 feet wide outside the Crown grant.

These ore deposits have been worked intermittently between the years 1889 and 1901. The ore was shipped to Tacoma, and to the Revelstoke Smelting Works.

From an open-cut on the main vein shipments of ore to the amount of 12,000 tons have been made. Later the ore was stoped at an elevation of about 150 feet above the upper terminal of the aerial tram. The vein here is about 15 feet wide. A tunnel has been run on the vein at the level of the upper terminal, and is now in about 125 feet; cross-cuts were run at 75 feet, and the face of the tunnel shows about 15 feet of ore.

The iron deposits consist of a number of veins or lodes, the general direction of which is northeast, and are vertical or dip northeast at high angles. One of the largest of these is situated about 700 feet horizontally from the Canadian Pacific Railway track, and about 450 feet above the same, and has been worked for several years, the ore being run down to the railway by means of an aerial tram.

McEvoy gives the following section of the veins:—

No. 1. An opening a few feet from the railway, filling an irregular, angular fissure from 2 to 6 feet in width. Between 1,000 and 1,500 tons mined.

No. 2. 300 feet south of No. 1, a deposit of 4 feet of good ore with 5 feet mixed ore and country rock.

No. 3. 500 feet southward from No. 2 a large deposit 14 feet of good ore, with 10 feet of mixed.

No. 4. 30 feet northwest of No. 3, 12 feet of ore.

No. 5. West of No. 4, in vein 3 feet thick.

No. 6. Southwest of No. 5, numerous croppings of good ore undeveloped. At a low estimate 10 per cent of the mass here is ore.

No. 7. Northwest of No. 3, a vein 4 to 10 feet thick. This is the principal source of output at present, and is connected with the railway by an aerial tramway.

The Glen mine ore is magnetite, and has the following composition:—

	No. 1.	No. 2.	No. 3.
Iron	64·81%	62·03%	63·24%
Moisture	Trace.	Trace.	Trace.
Silica insoluble matter	4·21	3·85	4·05
Manganese	Trace.	Trace.	Trace.
Alumina	3·78	3·08	3·05
Lime	1·00	3·85	3·46
Magnesia	0·39	0·24	
Sulphuric acid	0·158	0·170	0·17
Phosphoric acid	Trace.	Trace.	Trace.
Carbonic acid	None.	1·03	0·82
Combined water	0·66	0·55	0·48

Tested also for silver, copper, tungsten and titanium, but none found.

The iron reserves have been estimated at 8,000,000 tons, but the development work has not been extensive enough to prove up any such tonnage.

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ONTARIO.

Atikokan Iron Mine.

Owners: Atikokan Iron Company, Limited,
Port Arthur, Ontario, Canada.

The Atikokan iron mine is located on Mining locations E10, E11 and E12 on the Atikokan river, in the district of Rainy River. A spur 3 miles long connects the mine with the main line of the Canadian Northern railway at Iron Spur, 128 miles west of Port Arthur. (See maps Nos. 340 and 340A).

The Atikokan iron deposits were discovered in 1882 by Jim Shogonosh, an Indian trapper in the employ of Mr. G. McLaurin, of Savanne, Ontario. The latter interested Messrs. McKellar Bros. of Fort William, who applied for and acquired from the Government what are now known as Mining Locations E10 and E11. In 1905 the property was taken over by the present owners, The Atikokan Iron Company, Limited, of Port Arthur.

With the exception of a trench cut across the ore-bearing ridge in 1887 no development work was done until 1900, when a tunnel 5 feet by 6 feet was driven through the hill, a distance of 284 feet. In 1901 six diamond drill holes were put down. The tunnel was enlarged in the years 1907 and 1911. In 1911 and 1912 four additional tunnels were driven into the hill. Three exploratory shafts were started in 1912. One was discontinued at a depth of 47 feet, but Nos. 2 and 3 were sunk 150 and 126 feet respectively, and from the bottom of each of the latter a drift was driven across the ore-bearing zone. Since the completion of this work in 1913 all operations at the mine have been suspended.

Mining operations to supply the company's blast furnace at Port Arthur commenced in 1907 when a small output was shipped. Since then the mine has been operating and shipping ore during the years 1909, 1910, and 1911.

The most conspicuous feature of the Atikokan property is a steep narrow hill with a length of 3,800 feet, a maximum width of 400 feet, and a maximum elevation above the swamp, which surrounds it on all sides, of 100 feet. This hill is composed chiefly of dark basic rocks with which are interbedded irregularly-shaped, roughly lenticular, overlapping bodies of magnetite, some of which are impregnated with sulphides.

The irregularities in width and in chemical composition of the ore-lenses are illustrated by the following information secured from exploratory workings.

"A" tunnel is the most westerly of those driven in the ore-bearing hill. It cuts three lenses of ore with widths respectively of 7, 26, and 8 feet. The analyses of the ore in these lenses show the following range:—

Iron	45·1	per cent	—51·25	per cent.
Silica	4·9	"	—15·40	"
Sulphur	14·9	"	—18·80	"
Phosphorus	0·009	"	— 0·06	"

"B" tunnel is located 1185 feet east of tunnel A. It cuts 6 lenses of ore with widths of 12, 8, 24, 22, 9, and 5 feet respectively. The analyses of the ore showing in these lenses range as follows:—

Iron	45·9	per cent	—59·0	per cent.
Silica	8·3	"	—19·4	"
Sulphur	2·2	"	—12·3	"
Phosphorus	0·9	"	— 0·85	"

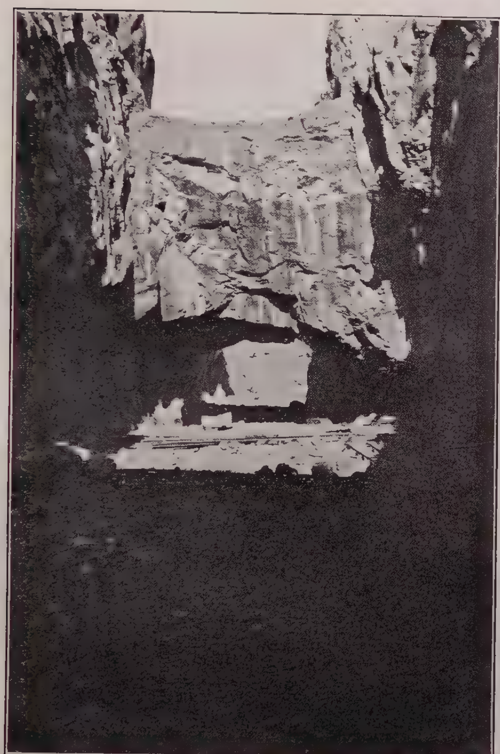
PLATE I.

Atikokan mine: general view of ridge.

PLATE II.

Open-cut, Atikokan mine.

PLATE III.



Open-cut, Atikokan mine.

"C" tunnel (the original exploratory tunnel) is 450 feet east of B tunnel. This cuts 2 ore-lenses with widths of 47 and 42 feet respectively. The ore shipped from the first-mentioned lens was of the following average composition:—

Iron	60·00	per cent.
Silica	8·50	"
Sulphur	2·01	"
Phosphorus	0·11	"

The average analysis of the ore cut in the northerly lens is as follows:—

Iron	47·68	per cent.
Silica	17·51	"
Sulphur	2·30	"
Phosphorus	0·193	"

"D" tunnel located 450 feet east of C tunnel cuts 2 lenses of ore with widths of 40 and 33 feet respectively. The ore mined from the first, or southerly one, averaged as follows:—

Iron	59·57	per cent.
Silica	8·41	"
Sulphur	2·17	"
Phosphorus	0·11	"

The section of the northerly lens exposed in the tunnel is of the following composition:—

Iron	59·40	per cent.
Silica	8·10	"
Sulphur	0·61	"
Phosphorus	0·041	"

"E" tunnel is located 510 feet east of tunnel D. This cuts 2 lenses of ore with widths of 47 and 17 feet respectively, and separated by 19 feet of rock. The average analyses of the sections of ore exposed in the tunnel are as follows:—

	South Lens.	*North Lens.*
Iron	48·86 per cent.	56·18 per cent.
Silica	15·90 "	11·05 "
Sulphur	12·90 "	1·97 "
Phosphorus	0·169 "	0·157 "

The ore as exposed in the workings is a hard, dense magnetite, difficult to mine, and of a refractory nature. Associated with it are pyrite and pyrrhotite in varying proportions, and also a little chalcopyrite. Phosphorus runs above the Bessemer limit, and nickel and copper are present in minute quantities.

As noted before, mining operations were carried on during the years 1907, 1909, 1910, and 1911. The bulk of the ore shipped has come from an open-cut about 300 feet long, 40 feet wide, and 60 feet deep, on the south side of the hill at C tunnel. Smaller quantities have come from a small open-cut at the south entrance of D tunnel and from exploratory work.

The total shipments from the mine to date amount to 86,433 long tons, and the average analysis of this ore was as follows:—

Iron	59·85	per cent.
Silica	8·68	"
Sulphur	2·01	"
Phosphorus	0·11	"
Alumina	1·51	"
Lime	3·00	"
Magnesia	2·54	"
Manganese	0·11	"
Copper	0·12	"
Nickel	0·11	"
Titanium	None.	

Because of its objectionable sulphur content, all this ore has to be roasted to prepare it for use in the blast furnace.

As regards the quantity of ore available for mining here, there are without doubt several millions of tons scattered through the ore-bearing zone. But the ore occurs in bodies very irregular, both in outline and in distribution, through the enclosing rock, causing the relative proportion of rock and ore over a given width of the ore-belt to vary greatly within even short distances. These considerations make any accurate estimate of tonnage of ore recoverable almost impossible. In addition, the variable and, in places, very high sulphur content, a matter seriously affecting the value of the ore, would have to be taken into consideration in any estimate of tonnage of *commercial* ore.

The surface equipment consists of three 100-H.P. boilers, furnishing power for operating the plant, one air compressor (981 cu. ft. per minute), one Austin gyratory crusher, crushing to 2½ inch size, with capacity of 50 tons per hour, necessary drills, ore cars, etc., blacksmith shop, office, warehouse, etc.

Camp accommodation for 100 men is provided.

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Atikokan mine, mine buildings.

Helen Mine (Hematite Deposit).

Owners: Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario, Canada.

The band of iron formation on which Helen mine is located has a length of 1¾ miles, and for three-quarters of a mile the width averages about 1,200 feet. It is composed chiefly of cherty and granular silica, usually massive, but in places slightly banded. In many places it has been badly crushed and brecciated. In subordinate amount there occur segregations of siderite, göthite, and hematite, which exploration has shown lie exclusively along the south side of the iron range. With the chert, granular silica and siderite, there is usually associated more or less pyrite; and in places, deposits of pyrites of merchantable grade and of considerable size exist.

Helen mine is situated on mining claims Nos. 68 and 69, in the southern part of township 29, range XXIV, in the district of Algoma. It is 11 miles distant by rail from Michipicoten harbour on Lake Superior, where is located the ore dock of the Algoma Central and Hudson Bay railway, at which lake vessels of 21 feet draft may tie up.

This mine has to its credit the largest iron ore production of any mine in the Dominion of Canada, the shipments of iron ore from the commencement of mining operations in 1900 to the end of 1915 having been 2,263,522 gross tons. Besides this there was shipped from 1906 to 1915 inclusive, 37,572 gross tons of iron pyrites. The ore-body has been almost completely worked over, and the comparatively small tonnage extracted during recent years has come principally from caved ore, and from pillars left when the ore was extracted by stoping. The ore is classified as an Old Range non-bessemer hematite, and because of its porous texture it is easily reduced in the blast furnace. Average analyses of 1914 shipments are as follows:—

	Helen No. 1.	*Helen No. 2.*
Iron	56·79 per cent.	57·76 per cent.
Silica	6·16	5·90
Sulphur	0·264	0·391
Phosphorus	0·095	0·092
Alumina	0·900	0·880
Lime	0·240	0·230
Magnesia	0·152	0·140
Manganese	0·170	0·165
Moisture	4·00	4·00

Guaranteed analyses for 1915 shipments are as follows:—

Helen No. 1. Iron, 55% natural. Sulphur under 0·200% dried.
" No. 2. " 53% " " " 0·400% "

Railway freight, in 1914, to Michipicoten harbour on Lake Superior was 50 cents per ton, and to Sault Ste. Marie, Ontario, $1 per ton.

All the mine plant is operated by electric power generated 12 miles distant at High Falls on the Michipicoten river. The hoisting and crushing equipment will handle an output of about 2,000 tons per 24 hours. The mine equipment includes a 150-H.P. electric hoist for skips, a 35-H.P. electric hoist for cage, a No. 6 Austin gyratory crusher, a 24-inch trough belt ore conveyer 240 feet long, four electric turbine pumps with a capacity of 1,500 gallons per minute against a 500-foot head, and a completely equipped machine shop for making all mine repairs.

A camp with water and sewage systems, and lighted by electricity and capable of accommodating about 500 people is maintained by the operating company.

The mine was developed from two shafts. No. 1 shaft sunk to the sixth level, a depth of 435 feet, is used for cage and ladderway. No. 2 shaft, started from about the same level as No. 1 shaft, was sunk as a 2-compartment shaft to the sixth level, and as a 4-compartment shaft to the ninth level at a depth of 651 feet. In 1912 the portion of No. 2 shaft above the fourth level was abandoned, and a new incline was driven from there to surface, making the total depth of the present No. 2 shaft 821·7 feet.

Probably about 45,000 feet of drifting, cross-cutting and raising was done in opening up the mine on the eight levels which have been worked. Prior to 1904 diamond drilling to the extent of 3,425 feet was done.

The main ore-body lay at the eastern extremity of a small lake called Boyer lake, which has been pumped out. In plan the deposit was roughly elliptical with, on the upper levels, a longer axis of 700 feet and a shorter axis of 200 feet. As greater depth was reached the major axis decreased in length, but at the same time the minor axis increased, with the result that about the same floor area of ore existed on each level except the eighth, where it is probably less than half as large as on the levels above. The ore-body had a pitch of about 60 degrees to the northeast. The vertical extent was about 700 feet.

On the south side the ore-body was bounded by country rock to the fifth level, and from that to the eighth by siderite; on the east it merged into lean ore generally; on the north it was bounded by a zone of iron-stained silica, succeeded by brecciated chert; and to the west it was bounded by a white to yellowish clayey dike, which, away from the ore-body, is really a medium-grained diabase. This dike appears to form the barrier in the iron formation against which the ore-body was deposited.

An interesting, though unfortunate feature of this deposit was the presence in it of pockets of pyritic sand varying in size from those containing a few cubic feet to others varying from 30 to 40 feet in their greater dimensions. These pockets were not numerous on the first level, but on succeeding levels the pyritic zone increased in size, thus raising the sulphur content

Helen mine, Michipicoten.

Crusher plant and shafts, Helen mine, Michipicoten.

of the ore hoisted, and resulting in a large tonnage of ore having to be left unmined.

To the west of the clayey dike lay a smaller ore-body first picked up on the third level at a depth of 280 feet. This has been worked on the third, fourth, fifth, and sixth levels. A considerable proportion of this ore was of Bessemer grade (in marked contrast to that of the main ore-body), but on the lower levels the ore was badly contaminated with pyrites.

The upper portion of the ore-body was mined in benches, and the ore was loaded into railway cars by steam shovels. From track level to the second level, at a depth of 164 feet, the greater portion of the ore was handled by milling methods. On the third, fourth, fifth and sixth level the ore was extracted by underhand stoping methods, pillars being left at intervals of about 50 feet to support the "back". On the seventh and eighth levels the ore is won by slicing and caving from sub-levels.

References:—
A. P. Coleman, and A. B. Willmot, Ontario Bureau of Mines, 1902, pp. 152–165.
A. P. Coleman, Ontario Bureau of Mines, 1906, p. 187.
R. W. Seelye, Journal of Canadian Mining Institute, 1910, pp. 121–134.
Plans and records furnished by Mines Department of Lake Superior Corporation, Sault Ste. Marie, Ontario, 1914. (George S. Cowie, Secretary.)
A. L. Parsons, Ontario Bureau of Mines, 1915, p. 202.
Annual Reports, Ontario Bureau of Mines, 1900–1915 inclusive.

Magpie Mine.

Owners: Algoma Steel Corporation, Limited., Sault Ste. Marie, Ontario, Canada.

The Algoma Steel Corporation's Magpie mine is located in the south-east quarter of township 29, range XXVI, in the district of Algoma. It is connected by a nine-mile spur with the Michipicoten division of the Algoma Central and Hudson Bay railway, by which access is had to Michipicoten harbour on Lake Superior, 26 miles distant, and to Sault Ste. Marie, 182 miles distant.

The claims comprising the Magpie mine property were staked in 1909 on several showings of magnetite. Exploration by trenching, stripping and test-pitting, and by diamond drilling was undertaken the same year, and was continued until the fall of 1910, this work showing the deposits to consist essentially of siderite, portions of which had been altered to magnetite.

In 1910 the sinking of a four-compartment shaft was commenced, and in 1911 the erection was undertaken of a roasting plant for the production of a marketable ore from the siderite, which had been shown to have an iron content of about 35 per cent, and an objectionable amount of sulphur.

The roasting plant was put in operation in December 1912, and was operated until October 1913, when it was dismantled to be replaced by a plant designed along lines suggested by the experience of the previous ten months. The new roasting plant went into operation in May 1914, and continued until October 31, when mining operations were suspended inde-

finitely on account of the depression in the iron a ' steel trade. In May 1915 mining operations were resumed, and the roas 'ng plant, with some modifications, was again put in commission, since which date operations have proceeded continuously.

The ore in this deposit is a hard, dense, fine-grained s.derite, most of which is more or less altered to magnetite. The colour varies from pale yellow, through grey, to black according to the proportion of magnetite present. Pyrite is rather plentifully present, always in such an amount as to give an undesirable sulphur content.

The ore-bodies stand about in the vertical and have a general east and west trend. They are enclosed in Keewatin rocks, greenstone being found usually on the north, and quartz-porphyry schist on the south.

Access is had to the mine by a four-compartment shaft. Two compartments of this shaft are used for ore-skips, one for a cage, and one for a ladderway and air, water and power lines.

Mining operations have been carried on on the first and second levels, the ore-body being developed for a length of 1,300 feet. The ore is mined by back-stoping from sub-levels. As all the ore mined has to pass through the roasting plant before shipment, no accurate record of tonnage of ore hoisted is kept. The output of the roast plant averages about 19,000 tons per month.

The total shipments of roasted ore to date have been as follows:—

In 1913	19,935	gross tons.
1914	98,070	"
1915	118,666	"
Total	236,671	"

The average analysis of the 1916 shipments of Magpie roasted ore is as follows:—

Iron	50·10	per cent.
Silica	9·14	"
Sulphur	0·136	"
Phosphorus	0·013	"
Alumina	1·28	"
Lime	7·96	"
Magnesia	8·04	"
Manganese	2·74	"
Loss by ignition	None.	

PLATE VII.

Magpie mine: general view.

PLATE VIII.

Magpie mine: head frame and roaster stacks.

PLATE IX.

Magpie mine: discharge end of cooling tube.

PLATE X.

Magpie mine: roasting plant and ore bridge.

PLATE XI.

Magpie mine: ore bridge and stock pile.

The composition of the raw ore is, according to the analysis of a sample taken by Mr. C. W. Knight of the Ontario Bureau of Mines in 1913, as follows:—

Insoluble	3·40	per cent.
$FeCO_3$	53·20	"
FeO	3·50	"
Fe_2O_3	8·40	"
$CaCO_3$	9·79	"
$MgCO_3$	11·57	"
$MnCO_3$	4·60	"
Iron (metallic)	34·30	"

The freight rates paid in 1914 were 50 cents per ton to Michipicoten harbour (including loading into boats), and $1 per ton all rail to Sault Ste. Marie, Ontario. The established lake freight from Marquette, Michigan, governs on shipments from Michipicoten harbour to Lake Erie ports.

The air compressor, a motor generator set, machine shop and blacksmith shop adequate for the requirements of mining, crushing and roasting operations, are located conveniently to the shaft.

The head frame is of steel and is 75 feet high. The crushers are three in number, one No. 8, and two No. 5 Austin gyratories. Troughed belt conveyers move the ore to the steel-bottomed stock bins, of which there are six, each with a capacity of 5,000 cubic feet.

The roasting kilns are six in number, each 8 feet in diameter and 125 feet long. At the upper end of each is a concrete dust chamber through which the waste gases pass on their way to the concrete stacks of which there are six, one for each kiln.

The fuel used for firing the kilns is pulverized coal, and the necessary machinery for crushing and pulverizing this is located adjacent to the roasting plant.

Rotary cylindrical coolers convey the hot ore to the stock yard, where it is distributed by an electric trolley bridge with drag-bucket of 80 cubic feet capacity.

All the mine equipment is operated by electricity generated at Steephill falls on the Magpie river, about 12 miles distant. The power line is connected at Helen mine with the Algoma Power Company's line from High falls on the Michipicoten river, so that power may be secured from that source in case of emergency.

The operating company has provided accommodation in camps and cottages for about 300 people. The camp is provided with water and sewage systems, and is lighted by electricity.

References:—
E. T. Corkill, Ontario Bureau of Mines, 1912, p. 113.
E. T. Corkill, Ontario Bureau of Mines, 1913, p. 106.
T. F. Sutherland, Ontario Bureau of Mines, 1914, p. 124.
Jas. Bartlett, Ontario Bureau of Mines, 1915, p. 105.
A. L. Parsons, Ontario Bureau of Mines, 1915, p. 199.
D. E. Keeley, Porcupine Branch Canadian Mining Institute, 1914.
Plans, records and information supplied by Mines Department, Lake Superior Corporation, Sault Ste. Marie, Ontario (Geo. S. Cowie, Secretary), 1915.

Moose Mountain Mine.

Owners: Moose Mountain, Limited, Sellwood, Ontario, Canada.
Property and Location.

The property of Moose Mountain, Limited, includes a number of low grade iron ore deposits included in an area of about 4 square miles, which extends from lot 6, concession III of the township of Hutton, district of Sudbury, northwesterly for 4½ miles into lot 1, concession VI of Kitchener township. The greater number of these deposits are grouped around the village of Sellwood.

Sellwood lies about 35 miles north of Sudbury, its nearest important centre, and is connected by a short branch line with the Toronto-Port Arthur line of the Canadian Northern railway, at Sellwood Junction. A few miles south of the French river, a six-mile spur from the main line of the Canadian Northern has been constructed to Key inlet on the Georgian bay, making a rail haul from Sellwood to Key harbour of 82 miles.

History.—Although the existence of deposits of banded iron formation here had been known since the early nineties, it was only in 1901 the exploration of these was undertaken. The first development work was done in 1906, and was on No. 1 deposit, and during 1907 a small crushing plant was installed at that point. The first shipment was made in 1908 when railway communication was established. The unfavourable reception this ore was accorded because of its low iron content led to the installation early in 1909 of a magnetic cobbing plant. Sufficient success attended the cobbing process to induce the owners to erect an enlarged cobbing plant, which was completed in 1910. The enlarged plant was in operation from August 1910 to May 1911, when it was closed down owing to unsatisfactory market conditions and complaints made by the buyers that the ore contained a too high percentage of fines. It was, therefore, necessary to screen the ore before further shipment could be made. This resulted in a considerable loss of magnetite in the fines.

The cobbing plant was put in operation again in 1912, and was operated until June 1914. The fines from this plant since 1912 have been taken care of in a Gröndal concentrating and briquetting plant erected that year for the purpose of treating the low grade siliceous ore comprising the major proportion of the company's ore reserves. Experimental operations

have been carried on intermittently at this plant since 1912, but as yet the plant has not been operating on a commercial basis.

Ore Deposits.—The ore deposits lie in a series of metamorphic schists of Archæan age, the chief constituents of which are hornblende, chlorite, feldspar and quartz. The more basic members of this series are prevailingly dark-green in colour, owing to the large amount of hornblende and chlorite present; while others, chiefly made up of feldspar and quartz, are of a lighter colour. The deposits have been upturned, faulted and folded together with these schists; their general strike and dip being, therefore, conformable to that of the latter, which generally is in a northwesterly direction, with a dip varying from 70 to 85 degrees towards the east. Locally, however, where the folding has been very intense, marked divergences in strike and dip frequently occur.

The existence of 11 ore deposits of all grades has been established by surface and diamond drill exploration and by magnetometric survey (see map No. 208c). These are divisible into two classes or types:—

Type A (including deposits Nos. 1 and 5. See map No. 205) consisting of magnetite associated with hornblende, pyroxene and epidote; and

Type B (including all deposits except Nos. 1 and 5. See maps Nos. 205, 206, 207, 208, 208a and 208b) consisting of fine-grained siliceous magnetite interbanded with siliceous material of both cherty and quartzitic texture.

Because of their irregular mineralogical composition, it is almost impossible to state what is the average iron content of deposits of type A. From them it has, however, been demonstrated by operations extending over a period of several years that there can be secured by magnetic cobbing a non-bessemer concentrate running about 55 per cent iron.

Deposits of type B average about 37 per cent iron, 45 per cent silica, and 0·055 per cent phosphorus.

Mining Operations.—Mining operations have so far been confined to deposits Nos. 1 and 5, which consist chiefly of ore of type A, that is, of magnetite associated with hornblende and epidote. The ore, until 1912, was won exclusively from No. 1 deposit from an open-cut with a face 60 to 70 feet high, and was trammed to a large bin discharging to a belt conveyer which delivered it to the cobbing plant. Since 1912 the ore from No. 1 deposit has been milled through raises and trammed on the 100-foot level to a 3-compartment shaft which is sunk to a depth of 180 feet.

At the cobbing plant the ore is crushed in a 24 by 36 inch jaw crusher. From the crusher the ore is conveyed to a storage bin of 800 tons capacity, whence it is fed to No. 4 gyratory crushers. The product from these crushers is screened to pass a 1-inch ring, the oversize passing to a Symons

48-inch disc crusher. The crushed ore is next passed over Ball and Norton single drum magnetic separators, giving two products, concentrates and tails. The concentrates are screened on an 8-mesh screen to rid them of dust.

Details as to yearly shipments of concentrates (which total 323,049 gross tons to the end of 1915), and average analyses of the same, are shown in the following statement:—

Yearly Shipments of Concentrates, 1908-1914.

Year.	1908	1909	1910	1911	1912	1913	1914
Shipments. Gross tons.	2,577	26,199	71,784	6,749	49,339	95,518	23,334
Analysis:—							
Iron.......	....	55·45%	54·60%	....	54·30%	55·50%	54·45%
Silica......	....	12·67	14·29	....	14·54	14·15	14·55
Sulphur ...	....	0·074	0·029	....	0·031	0·027	0·036
Phosphorus	....	0·017	0·091	....	0·099	0·099	0·105
Alumina...	....	1·58	1·92	....	1·83	2·03	2·09
Lime......	....	3·77	3·82	....	3·97	3·26	4·00
Magnesia..	....	3·52	3·64	....	3·64	3·06	2·83
Manganese	....	0·09	0·06	....	0·07	0·09	0·07
Loss by ignition..	....	....	0·63	....	0·48	0·42	0·75

The dust from the No. 1 plant has, during recent years been ground, concentrated and briquetted at the Gröndal or No. 2 plant. Particulars as to shipments of briquettes during 1913 and 1914, and average analyses of the same are shown in the following table:—

Shipment of Briquettes and Analyses of same, 1913-1915.

Year.	1913.	1914.	1915.
Shipments, gross tons.	3013	5466	1680
Analysis:—			
Iron..................................	63·03%	63·02%	63·02%
Silica..................................	6·05	6·66	6·66
Sulphur..................................	0·014	0·012	0·012
Phosphorus..................................	0·028	0·037	0·025
Alumina..................................	0·93	1·00	1·00
Lime..................................	2·00	1·50	1·50
Magnesia..................................	1·49	1·53	1·53
Manganese..................................	0·06	0·08	0·08
Loss by ignition..................................	None.	None.	None.

Freight Rates.—The freight rates existent in 1914 on iron ore shipments from Sellwood were as follows:—

To Sault Ste. Marie, all rail		$1.60
„ Parry Sound,	„ „	1.00
„ Deseronto,	„ „	1.55
„ Key Harbour	(including loading into boats to U.S. ports)	.55
„ „ „	(including loading into boats to Canadian ports)	.65

The lake freight from Key harbour to Lake Erie ports in 1913 was 40 cents, and in 1914 it was 35 cents.

Ore Reserves.—The ore reserves consist of deposits of type A, with an area of 71,000 square feet, and those of type B with an area of 3,185,000 square feet (see maps). Data for making a reliable estimate of tonnage of either type are insufficient.

It being evident that only a limited tonnage of concentrates of the grade already produced is still available from deposits Nos. 1 and 5, the owners realize that the problem to be solved is the economical production of a marketable product from deposits of type B. The total area of all deposits is about 3,256,000 square feet, and assuming an average specific gravity of 3·8 for the ore, the deposits, for each 100 feet in depth, should yield about 38,665,000 tons of siliceous ore; and with a proven depth of at least 300 feet for portions of two deposits, it is probable that the figures of tonnage just mentioned may be much below the tonnage of siliceous ore actually available for mining.

Experiments carried out by Moose Mountain, Limited, indicate that 2·1 tons of ore of type B are required to furnish one ton of concentrates averaging 65 per cent iron. On this basis the ore deposits for each 100 feet of depth would probably yield about 18,500,000 tons of concentrates. The crushing would probably have to be carried to 160 mesh to get a satisfactory separation of magnetite from gangue, but the resulting concentrate would have a high iron content and be of Bessemer grade.

The concentrates necessarily have to be agglomerated in some way for satisfactory handling and for use in the blast furnace, and this Moose Mountain, Limited, has attempted to do by briquetting, the briquettes being burned in gas-fired kilns.

The first of the two analyses given below indicates the chemical composition of the crude ore type B, and the second that of the briquettes produced in 1914, which were made from dust from the cobbing plant or No. 1 mill. Briquettes made from concentrates from ore of type B, would likely be of about the same composition as those already made, except as to the content of phosphorus, and of manganese which it is expected would be lower.

	Crude Ore Type B. %	Briquettes shipped, 1914. %
Iron	36·70	63·02
Silica	45·20	6·66
Sulphur	0·019	0·012
Phosphorus	0·057	0·037
Alumina	0·25	1·00
Lime	1·06	1·50
Magnesia	1·59	1·53
Manganese	0·04	0·08
Loss by ignition	0·15	None.

Surface Equipment.—The surface mining equipment consists of two 2,000-cu. ft. compressors, one 150-H.P. double drum hoist, two belt-driven tram hoists, necessary tram cars, tracks, etc., and blacksmith and machine shops.

There are two mills, No. 1 for treating ore of type A, and No. 2 (or Gröndal plant) for fine grinding, magnetic concentration and briquetting, the latter with a rated capacity of 800 tons of crude ore per 24 hours.

Power.—All the equipment is electrically operated by power brought in over the company's own transmission line from the Wanapitei Power Company's plant 35 miles distant, the power being paid for at the power company's switchboard at the rate of $16 per horse power per year based on the peak load.

References:—
W. H. Collins, Geol. Sur. Can., Summary Report, 1912, p. 312.
E. Lindeman, Moose Mountain Iron-Bearing District, Mines Branch, Ottawa, 1914, No. 303.
Fred A. Jordan for Moose Mountain, Limited, Sellwood, Ontario, 1914.

Blairton Mine.

The Blairton iron mine is situated on lots 7 and 8, concession I, in the township of Belmont, Peterborough county. It lies on the shore of the southwest end of Crow lake about 5 miles west of the village of Marmora, and about 3 miles northeast of Blairton station on the Canadian Pacific railway. The distance from Blairton station to Trenton by rail is 34 miles.

The mine was opened up about 1820, and was operated intermittently until 1875. During these years very considerable tonnages of ore were shipped. In 1908 some diamond drilling was done, and in 1910 thirteen holes, with an aggregate footage of 3,600 feet were put down. No exploration or development has been done by the present owners.

The area surrounding the ore-bodies is chiefly occupied by hornblende and chlorite schist and crystalline limestone, in contact with diorite (see

PLATE XII.

Open-cut at Blairton mine.

PLATE XIII.

Pit No.1 at Blairton mine.

map 185a). The general strike of the stratified rocks is about N. 15° W. with a steep dip towards the east.

The ore deposits consist of magnetite, which occurs along the contact of the crystalline limestone and diorite, and is associated with various metamorphic rocks. In some parts of the field the magnetite is found in well-defined layers interstratified with these rocks: in others, finely disseminated throughout the same.

Judging from the magnetometric survey, the ore occurs in two separate areas. On the more southerly of these areas ore has been mined from two open pits, No. 1 and No. 2. The total area of these two pits is 27,500 square feet. The depth of pit No. 1 is 125 feet. By a diamond drill hole the deposit has been proved to a depth of 550 feet.

The other area has been opened up by a large open-cut on the hillside near Crow lake. Judging from the magnetometric survey (see map 185), the total length of this deposit may be roughly estimated at about 560 feet, its northern end extending about 130 feet under the lake. On the hillside immediately west of the open-cut several strongly positive magnetic areas, alternating with some strong negative ones, indicate an irregular distribution of the magnetite throughout the rock.

The total area within which ore is likely to occur in this part of the field is roughly estimated at 128,000 square feet, but no doubt a large percentage of this area is occupied by barren rock.

The ore consists of a finely crystalline to massive magnetite, with a gangue of pyroxene and calcite. In the northern ore-body there is a good deal of finely disseminated pyrite.

The ore extracted was won from three open-pits, the Lake pit on an ore-body close to Crow lake, and the Derrick and Morton pits on another ore body about 1,000 feet farther south. One of the two latter is 200 feet long, and 150 feet wide, and is reported to be 125 feet deep. All the pits are now filled with water.

No record of the total tonnage of ore shipped is now available, but the amount is estimated to have been from 250,000 to 300,000 tons. The average composition of these shipments is not known, but it appears from the piles of waste ore on the property that only an ore of high iron content was shipped. An average sample across the north end of the Lake pit taken by E. Lindeman in 1911 gave the following analysis:—

Iron	50·10 per cent.
Silica	9·88 " "
Sulphur	1·42 " "
Phosphorus	0·046 " "
Alumina	1·73 " "
Lime	3·52 " "
Magnesia	1·64 " "
Titanium dioxide	0·10 " "

No information as to cost of mining and selling price of the ore shipments is available. The freight rate to the Pittsburgh district, where the ore was shipped, is reported to have been about $4 per ton.

To transport ore from the mine it would be necessary to build a railway spur 6 miles long to the Central Ontario railway. The freight rate to Trenton would probably be about 40 cents per ton.

There is a small amount of mining equipment on the property, but it is all obsolete, and would have to be replaced if mining operations were undertaken.

References:—

R. H. Flaherty, Port Arthur, Ontario, 1904.
E. Lindeman, Mines Branch, Ottawa, Publication No. 184, p. 9.
W. J. McLaughlin for Canada Iron Mines, Limited, Trenton, Ontario, 1914.

Belmont (or Ledyard) Mine.

Owners: The Canadian Furnace Company, Limited, Port Colborne, Ontario.

The Belmont iron mine is situated on lot 19, concession I of Belmont township, County of Peterborough, about 8 miles northwest of Marmora. It is connected with the Central Ontario railway by a branch line known as the Ontario, Belmont and Northern railway. The distance from the mine to Trenton, on Lake Ontario, by rail, is about 39 miles.

This property was operated many years ago, ore being extracted from No. 1 and No. 2 (or Nichol) pits (see maps Nos. 186 and 186a). In 1911 the former had a length of 220 feet, a width varying from 40 to 70 feet, and a depth of from 3 to 20 feet; and the latter (located 100 feet southeast of No. 1) had a length of 55 feet, a width of 40 feet and a depth of 5 to 6 feet. Six diamond drill holes put down in 1906 are said to have proven 200,000 tons of concentrating ore. (W. W. J. Croze.)

In 1911 development work was resumed after a lapse of several years. A 3-compartment shaft, started that year about 15 feet north of No. 1 pit had reached a depth of 260 feet early in 1914, when mining operations were discontinued. Levels were opened from this shaft at depths of 100, 170, and 230 feet. In 1913 the Mines Inspector reported that the cre-body appeared to be widening at depth, and the grade of ore improving.

The character of the iron-bearing formation varies considerably. In some places it consists of almost pure magnetite, in others of a mixture of magnetite and gangue minerals, chiefly pyroxene and chlorite; in other places again the latter minerals prevail almost to the exclusion of the magnetite. Iron pyrites is frequently seen throughout the ore. The ore-body lies along a contact between crystalline limestone and diorite.

An analysis of an average sample taken from the north end of No. 1 pit by E. Lindeman in 1911 is given herewith:—

Iron	51·20	per cent.
Silica	12·10	" "
Sulphur	0·34	" "
Phosphorus	0·032	" "
Lime	4·87	" "
Magnesia	3·93	" "
Titanium	0·10	" "

Since the resumption of mining in 1911 the shipments have aggregated 5,746 short tons, the shipments by years being as follows: 126 tons in 1911, 28 tons in 1912, and 5,592 tons in 1913.

Judging from the magnetometric survey (see maps 186 and 186a), confirmed by a few natural exposures, the area within which the ore is likely to occur may be roughly estimated at 4,300 square feet, but a large percentage of this area is undoubtedly occupied by barren rock.

References:—
Dr. Eugene Haanel, Report of Superintendent of Mines, Ottawa, 1906, p. 5.
W. W. J. Croze for R. H. Flaherty, Port Arthur, Ontario, 1906.
E. T. Corkill, Ontario Bureau of Mines, 1912, p. 158.
E. T. Corkill, Ontario Bureau of Mines, 1913, p. 134.
T. F. Sutherland, Ontario Bureau of Mines, 1914, p. 171.
E. Lindeman, Mines Branch, Ottawa, Publication No. 184, 1913, p. 10.

Bessemer Mines.

Owners: Canada Iron Mines, Limited, Trenton, Ontario.

The Bessemer property includes lots 2, 3, 4 and 5, concession VI, and lot 1, concession VII, in the township of Mayo, county of Hastings. A railway spur, 5 miles long, known as the Bessemer and Barry's Bay railway connects the mine workings with the Central Ontario railway at L'Amable, which is 78 miles north of Trenton, Ontario, where is located a magnetic concentrating plant owned by Canada Iron Mines, Limited.

The Bessemer and other ore deposits in this locality were first exploited by Mr. H. C. Farnum, who in 1902 organized the Mineral Range Iron Mining Company, which assumed the ownership of them. By this company the properties were opened up and shipments of ore were made in 1902, 1903, 1906, and 1907.

In February, 1908, the Canada Iron Furnace Company leased the properties of the Mineral Range Iron Mining Company, and operated them until May 1910, when they surrendered their leases. The mines then lay idle until 1911, when the properties were acquired by the Canada Iron Mines, Limited, who operated them in 1912 and 1913 to supply their concentrating plant at Trenton. Since 1913 the mines have been idle.

The ore deposits occur as isolated lenses of varying extent, associated with a limestone-amphibolite series, along, or adjacent to, a granite contact (see map 191a).

The general strike of the formation is northeast-southwest, with a steep dip towards the southeast, averaging about 60 degrees. The ore consists of fairly coarse-grained magnetite. Its quality varies greatly in different parts of the deposits. In some cases a clean magnetite of high iron content is observed; in others, the magnetite is closely associated with garnet, hornblende, epidote, and calcite, and the ore often appears to pass gradually into such gangue minerals.

The best quality of the ore averages about 54 per cent iron, but considerable cobbing has to be done in order to keep it up to that standard, as a large percentage of the ore does not average more than 40 to 48 per cent iron.

This latter ore was, until 1911, relegated to the waste dumps, or left in the mine. Locally, stringers and patches of iron pyrites are found, but by hand cobbing the ore it was found possible to keep the sulphur down to somewhere near 0·07 per cent. The percentage of phosphorus is very low, averaging from 0·010 to 0·025 per cent.

Since the completion of the concentrating plant at Trenton, the ore is no longer cobbed at the mine, but is shipped as mined.

While the presence of a large number of ore-lenses of different size is known, mining operations have been confined to four (see maps Nos. 191 and 191a), which will be described in order from west to east.

Deposit No. 1, on lot 1, concession VII, was developed as an open-pit, and a small tonnage of ore has been shipped from it. The ore in this pit is badly mixed with gangue minerals, chiefly hornblende. The presence of a number of small ore-lenses adjacent to deposit No. 1, is indicated by the magnetometric survey by E. Lindeman.

Deposit No. 2, is one of a group of deposits on lot 2, concession VI, all of which the magnetometric survey indicates as being very small. It has been developed as an open-cut from which a little ore was extracted. The workings show the magnetite to be intermixed with various gangue minerals.

Deposit No. 3, is located on lot 3, concession VI, and is about 1,300 feet east of No. 2. It consists of two open-pits, which have been opened up on two ore-lenses separated from each other by about 50 feet of gangue rock, through which a small amount of magnetite is disseminated; the smaller pit is 40 feet by 90 feet and 6 feet deep, and the larger is 60 feet by 60 feet and 20 feet deep. About 5,000 tons of ore were shipped from these workings.

From the bottom of the larger pit a drill hole was put down, and it was still in ore at 160 feet when discontinued.

In addition to the two lenses opened up the magnetometric survey indicates, a short distance east and west of these workings, several other deposits, all of which are, however, covered by drift.

PLATE XIV.

No. 4 mine, Bessemer.

PLATE XV.

No. 3 mine, Bessemer.

Plate XVI.

Open-cut, No. 4 mine, Bessemer.

Deposit No. 4, the largest and richest of the Bessemer group, is situated on lots 4 and 5, concession VI. According to the magnetometric survey, the total possible length of this deposit may be estimated at about 1,000 feet, the western end extending 400 feet under Little Mullet lake. The average width of the deposit is roughly estimated to be about 50 feet (see maps 191 and 191a).

This deposit was first worked as an open-pit, and from this a very considerable tonnage was extracted, the pit being carried to a depth of 80 feet. Operations in recent years have been conducted from a 3-compartment shaft started in 1908. The shaft is inclined to the southeast at 65 degrees, and has a depth of 236 feet, and from it levels have been opened at depths of 55 feet, 101 feet, 161 feet, and 236 feet respectively. On the 2nd level the length of the workings in ore is 495 feet, and on the 3rd it is 525 feet. The present workings have proven ore to a greater depth than did the diamond drill holes put down a few years ago.

Judging from the results of the magnetometric surveys, confirmed by the distribution of a few natural exposures, we may estimate the total ore area of the seven largest deposits to be about 83,000 square feet, of which 50,000 are attributed to No. 4 deposit.

This estimate does not, however, pretend to be more than a very rough approximation; besides, a considerable portion of this area contains, no doubt, ore which has too low iron content to be suitable for economic iron smelting without previous concentration.

In order to ascertain the suitability of the ore for magnetic concentration, tests have been made at the Ore Dressing laboratory at Ottawa on a shipment of 1·5 tons of discarded ore from No. 4 mine. The sample was crushed down until 50 per cent of the ore passed through 200 mesh, and separated by the Gröndal wet process. The result of the test is shown in the following table:—

Analyses of Crude Ore, Concentrates, and Tailings.

	Crude ore.	Tails.	Concentrates.
Iron	36·50%	4·5%	67·4%
Insoluble matter	35·37	...	5·87
Phosphorus	0·026	...	0·007
Sulphur	0·314	...	0·185
Lime	5·68	...	......
Magnesia	0·030	...	......

It will be seen from the above figures that 1·96 tons of this material is required to make 1 ton of concentrate with an iron content of 67·4 per cent. The percentage of iron in the crude ore saved in the concentrate is 94 per cent, while about 6 per cent of the iron content of the ore is lost in the tailings. The phosphorus, although below Bessemer limit, in the

crude ore, has been depressed to a point that should make the concentrate very valuable for the production of special low phosphorus iron.

All ore shipped from the Bessemer property prior to the opening of the concentrator at Trenton was hand-sorted. Since then the ore is shipped as mined.

The shipments to the end of 1914 are reported as follows:—

From No. 1 deposit....	700	gross tons (hand sorted).	
" " 2 "	1,500	" " " "	
" " 3 "	5,000	" " " "	
" " 4 "	92,413	" " (" "	and crude).
Total.................	99,613		

The two following analyses were furnished by the Midland Blast Furnace, No. 1 representing ore received from Bessemer mines in 1907, and No. 2 a 25-car shipment received in 1908.

	No. 1.		No. 2.	
Iron....................	54·29	per cent.	54·00	per cent.
Silica....................	9·84	" "	......	
Sulphur..................	0·062	" "	0·075	"
Phosphorus..............	0·019	" "	0·022	"
Alumina................	2·02	" "		
Lime....................	6·86	" "		
Magnesia................	1·35	" "		
Manganese..............	0·38	" "		

Two average samples of discarded ore from No. 4 mine gave the following analyses:—

	No. 1.		No. 2.	
Metallic iron, Fe.........	47·70	per cent.	42·50	per cent.
Lime....................	8·75	" "	13·05	" "
Magnesia................	4·07	" "	2·80	" "
Alumina................	2·34	" "	2·79	" "
Silica....................	15·30	" "	19·20	" "
Phosphorus..............	0·004	" "	0·30	" "
Sulphur..................	0·63	" "	0·30	" "

The mining plant is operated by steam, two 150-H.P. boilers being installed for this purpose. The mining equipment includes an air compressor (with a capacity of 1,400 cubic feet of free air per minute), one 6-K Gates crusher and the necessary hoists, drills, etc.

Camps and cottages for accommodating the employees are maintained by the operating company.

Childs property.

References:—
Ontario Bureau of Mines, Mines Inspector's Reports. 1902–1912 inclusive.
Geo. C. Mackenzie, Ontario Bureau of Mines, 1908, p. 221.
E. Lindeman, Mines Branch, Ottawa, Publication No. 184, p. 16.
W. J. McLaughlin for Canada Iron Mines, Limited, Trenton, Ontario, 1914.

Childs Mine.

Owners: Canada Iron Mines, Limited, Trenton, Ontario.

The Childs mine is located on the south halves of lots 11 and 12, concession IX, in the township of Mayo, county of Hastings, about 3 miles east of the Bessemer mine, with which it is connected by the Bessemer and Barry's Bay railway.

The property was first exploited by Mr. H. C. Farnum, and later by the Mineral Range Iron Mining Company. Very little work was done on it prior to 1913, when the present owners made a systematic exploration of it, and commenced mining operations. Since 1913 the mine has not been in operation.

The ore deposits are found in mica schist, and lime-amphibolite rocks near their contact with granite and other igneous rocks (see maps 192 and 192a). The magnetic survey indicates that this property is likely to contain ore bodies of considerable size.

The ore is a coarsely crystalline magnetite usually intermixed with a gangue of garnet, epidote, calcite and other minerals.

An average sample taken across the ore-body by E. Lindeman gave the following analysis:—

Iron	42·00	per cent.
Silica	12·53	" "
Phosphorus	0·066	" "
Sulphur	0·160	" "
Lime	7·75	" "
Magnesia	2·00	" "
Titanium	0·10	" "

In 1913, four working faces were stripped and opened on that portion of the deposit lying above swamp level, and ore was broken in open-cuts. It is proposed to operate the deposit as an open-pit to the depth permissible by condition of the walls, and after that to introduce a milling system of mining.

The mining equipment consists of two 75-H.P. boilers, one 5-K Gates crusher, crusher engine, hoist, locomotive, mine cars and steam drills.

A small camp is maintained for the accommodation of the employees.

References:—
Mines Inspector's Reports, Annual Reports, Ontario Bureau of Mines, 1902–1915 inclusive.
E. Lindeman, Mines Branch, Ottawa, Publication No. 184, p. 19.
W. J. McLaughlin for Canada Iron Mines, Limited, 1914.

Coehill Mine.

Owners: Canada Iron Mines, Limited, Trenton, Ontario.

This mine is situated on lots 15 and 16, concession VIII, in the township of Wollaston, county of Hastings, and it is connected by a branch line 7 miles long, with the Central Ontario railway at Ormsby junction. The distance by rail from the mine to Trenton is 73 miles.

The mine was opened in the early eighties, and shipments were made from 1884 to 1887 inclusive. It is reported that during this time the quantity of ore mined was between 80,000 and 100,000 tons, about one-third of which was left in stock piles. The high sulphur content of the ore prevented a market being found for it.

Small shipments were made from ore in stock in 1900 and 1909. In 1910 six diamond drill holes, averaging 450 feet in depth were put down. The property is now owned by Canada Iron Mines, Limited, but it has not as yet been operated by them.

The main ore-body is well exposed on the hill north of the railway track by two open-pits. The general trend of the formation is northeast-southwest, with a dip of about 50 degrees towards the southeast. The deposit seems to form part of a limestone-amphibolite series, locally enriched in iron by the intrusion of syenite, which cuts the series in the most intricate manner. The ore consists of a fine-grained magnetite, associated with hornblende, pyroxene and calcite. It has a streaked or stratified appearance parallel to the strike, which is due to the variation in the relative amount of the constituent minerals present. Some streaks are very rich in magnetite, while others are composed of pyroxene and hornblende. The average sulphur content of the ore is high, a considerable amount of pyrite and pyrrhotite being disseminated throughout the ore.

In addition to the main ore-body the existence of several others to the north is indicated by Lindeman's magnetometric survey (see maps 190 and 190a).

The mine was operated as an open-cut at first, and later from three shafts. No. 1, shaft, reported to be 95 feet deep, was sunk on a deposit which the magnetometric survey indicates to be of very small extent (see map 190). No. 2 and No. 3 shafts at the main ore-body are reported to have depths of 130 and 100 feet respectively. All the old workings are now filled with water.

The total shipments from the property between 1880 and 1914 are reported to have been 54,783 long tons. No analyses of the ore shipped are available, but an average sample taken across the ore-body by E. Lindeman gave the following analysis:—

Iron	47·30	per cent.
Insoluble	30·90	" "
Sulphur	2·21	" "
Phosphorus	0·018	" "

Plate XVIII.

Shaft No. 3, Coehill mine.

The mining equipment installed in the early days of the mine has not been dismantled, but it would have to be replaced by up-to-date equipment if the mine were operated.

References:—
E. Lindeman, Mines Branch, Ottawa, Publication No. 184, p. 14.
W. J. McLaughlin for Canada Iron Mines, Limited, Trenton, Ontario, 1914.

QUEBEC.

Bristol Mine.

The Bristol mine is situated on the north half of lots 21 and 22, range II, in the township of Bristol, county of Pontiac, about 4·8 miles northwest of Chats falls on the Ottawa river. A standard gauge railway 4¼ miles long, connects the mine with Wyman station on the Ottawa-Waltham branch of the Canadian Pacific railway.

The first work dates back to the winter of 1872-3, when the north halves of lots 21 and 22 were leased to an American syndicate and some openings made. No ore was shipped and after some years the lease was allowed to expire. In 1883 the properties were leased to another syndicate, and mining operations started in the autumn of 1884. These operations, however, were confined to lot 21, and chiefly to shaft No. 1. A compressor and hoisting plant were installed, and necessary shops erected. As the ore contained considerable iron pyrites, two roasting kilns with six gas producers were built, and the ore was crushed and roasted before shipment was made. Operations were carried on, with several interruptions, until 1894, when the mine was closed down. Since that time no attempt has been made to re-open it, and at present all the workings are filled with water.

Geologically, the area presents a series of schists and gneisses, associated with crystalline limestone, all of which are cut by granites. The strike of the bedded rocks varies from N. 70° W. to N. 42° W., with a dip towards the north varying from 35° to 89°.

A magnetometric survey made by E. Lindeman, in 1909, indicates the existence of three areas in which the vertical magnetic attraction is very strong (50° or more). These areas are respectively 25,000, 60,000, and 90,000 square feet, and in addition there are other areas of less importance. (see map 441).

During 1910, Ennis and Company of Philadelphia made several trenches in the areas of strong magnetic attraction, showing that the formation is not uniformly made up of magnetite, but that the ore-bodies constitute a series of lenticular masses or bands of magnetite, with a certain percentage of hematite in places; none of the lenses show a width of clean ore greater than 40 feet. The magnetite is generally interbanded with mica and hornblende schist, in which it is often abundantly disseminated. The whole series of these foliated rocks is cut by intrusions of granite.

Though the ore deposit cannot be said to cover the same surface area as the lines of strong magnetic attraction, it is possible that in these areas the magnetite bands are so frequent and the inclosing rocks so impregnated with disseminated magnetite that the whole deposit could be worked. In such a case special treatment will be required both for increasing the percentage of iron and for decreasing the percentage of sulphur. The property is considered worthy of further exploration in the form of diamond drilling.

At present the development work is not sufficient to make any estimate of the reserves of ore.

The following analyses represent average samples of 100 pounds taken from two of the largest ore-piles at the mine.

	1.	2.
Metallic iron	58·180 per cent.	53·740 per cent.
Sulphur	1·480 " "	2·920 " "
Phosphorus	0·008 " "	0·007 " "

In 1909, in addition to the magnetometric survey of the property, magnetic concentration experiments on Bristol mine ore were carried on by Mr. G. C. Mackenzie, of the Mines Branch, Ottawa. The results from this work showed that a concentrate high in iron, and low in phosphorus, could be obtained. The objectionably high sulphur content of the concentrates would be reduced by the nodulizing or sintering processes required to put the concentrates in suitable form for blast furnace use.

References:—
Cirkel. Report on the Iron Ore Deposits along the Ottawa and Gatineau rivers, Mines Branch No. 23, pp. 75–90.
Lindeman and Mackenzie. Mines Branch, Iron Ore Deposits of Bristol Mine, No. 67.
Dulieux. Report on Mining Operations in Quebec for 1912, pp. 107–114.

NEW BRUNSWICK.

Bathurst Mines.

Owners: Canada Iron Corporation, Limited, Montreal, Que., (in liquidation).

The Bathurst iron mines are situated in Gloucester county, New Brunswick, about 21 miles southwest of the town of Bathurst, in the vicinity of Austin brook, a small tributary of the Nipisiguit river. In November, 1907, these deposits were acquired by the above company, and mining operations were started after a branch line had been built connecting the property with the Intercolonial railway at Blacks cut about 4 miles south of Bathurst, the distance from the mine to Blacks cut being about 17 miles. Docks for the transhipment of the ore have been built at Newcastle, the railway haul from the mine to the docks being 57 miles. The ore pocket has a capacity of 13,000 tons, and the dock has a loading capacity of 3,000 tons per hour. Ocean vessels drawing 21 feet may dock. In 1911 a concentrating plant to treat the ore before shipment by crushing,

Bristol Mine, Pontiac county, Que., 1894.

screening, and jigging was erected at the mine. The results obtained, however, were not satisfactory. Mining operations were discontinued in 1913 when the company went into liquidation.

The following shipments have been made:—

1910	4,764	gross tons.
1911	27,786	„
1912	63,857	„
1913	76,665	„
1914	4,400	„
1915	3,288	„
Total	180,760	„

Ore Reserves.—The estimate by E. Lindeman is based on information from his magnetometric surveys, surface outcrops and diamond drill holes. The total horizontal area of ore, in all the deposits is placed at 314,000 square feet. The crude ore is assumed to have specific gravity of 3·8, the quantity of ore would be approximately *3,720,000* tons for every 100 feet of depth. Assuming a vertical depth of 500 feet for all the deposits, which is approximately the vertical depth to which deposit No. 1. of group No. 1 has been proved, the probable ore amounts to *18,600,000* tons. This ore is too low grade to be marketed in its natural state. It would be necessary either to concentrate it or to follow a method of selective mining, and stope ore of a certain grade only.

A report submitted by the Canada Iron Corporation says No. 1 deposit has an estimated reserve of *3,800,000* tons, and No. III, assuming a length of 2,000 feet, width 60 feet and depth 350 feet, from magnetometric survey and bore holes, an estimated reserve of *3,360,000* tons.

Composition of the Ore.—The following analyses show the average composition of the ore:—

	No. 1.	No. 2.	No. 3.
Iron	43·7	46·6	47·5 per cent.
Insoluble	26·3	24·7	22·7 „ „
Phosphorus	0·64	1·04	0·65 „ „
Sulphur	0·05	0·02	0·05 „ „
Manganese	1·00	1·8	1·2 „ „

1. Average sample..............Group I.
2. „ „ Deposit No. 2, „ II.
3. „ „ .... „ III.

Ore-Bodies.—The ore occurs as elongated lenses in a schistose quartz-porphyry, and consists of a very fine-grained siliceous magnetite, mixed with a considerable amount of hematite. It is often interbanded with jasper and a green slaty gangue material, which give the deposits a con-

spicuous bedded structure. Veins of quartz are of common occurrence, and generally follow the bedding planes of ore. The metallic iron content of the various layers varies, therefore, considerably, ranging from 59 down to 35 per cent, the average being about 46·18 to 48·1 per cent.

The average phosphorus content is about 0·8 per cent with manganese 2·7 per cent locally and sulphur ranging from 0·03 to 0·1 per cent; but locally the sulphur content is much higher. This is especially the case near the contact of the ore with the country rock, where layers of iron pyrites. varying in thickness from a fraction of an inch up to several feet, often occur.

The ore-bodies lie in three main groups, which for reference are numbered I, II, and III (see map No. 106).

Group I is situated west of Austin brook, and consists of one ore-body, the total length of which is about 2,150 feet. The northern end of this deposit is well exposed, rising abruptly to a height of 75 feet above Austin brook. Farther south it is covered by gravel of considerable depth, but it outcrops again about 100 feet from the Nipisiguit river, where its contact with the schistose porphyry is well exposed. Diamond drilling showed the deposit to dip at an angle of about 60° to the west, and close to surface to have thicknesses of 106 and 8 feet at the north and south ends, respectively, and a thickness of 60 feet near the centre. A deep hole near the centre showed the ore-body to have a thickness of 64 feet at a depth of about 500 feet.

Group II lies east of Austin brook, and is made up of several ore-lenses, which for reference are numbered 1, 2, 3 and 4.

No. 1 deposit outcrops on the hill slope towards the Nipisiguit river, and is, according to the magnetic survey, of inconsiderable extent. Deposit No. 2, on the eastern bank of Austin brook, is probably 250 feet long, and has widths of 19 and 42 feet at the north and south ends, respectively. No. 3, is almost completely covered by humus, but is probably 350 feet long. No. 4 has a length of 400 feet, and a maximum width, at the south end, of 30 feet.

Between Groups II and III, 1,600 feet apart, the magnetometric survey gives no indication of ore deposits (see map No. 107). The deposits comprising Group III are almost entirely overlain by drift. The iron-bearing area has a length of about 4,400 feet, and probably contains a great number of ore-lenses which vary considerably in size. On the chief deposit two drill holes, Nos. 5 and 6, were put down, No. 5 cutting ore similar to that in Group I to a depth of 327 feet, and No. 6 revealing only lean ore with bands of jasper. This deposit has an average width of 100 feet and is probably 830 feet long. About 150 feet north of this deposit another ore-lense is situated, on which drill hole No. 7, cutting ore similar to that in the other deposits, was sunk. This ore-body has a total length of about

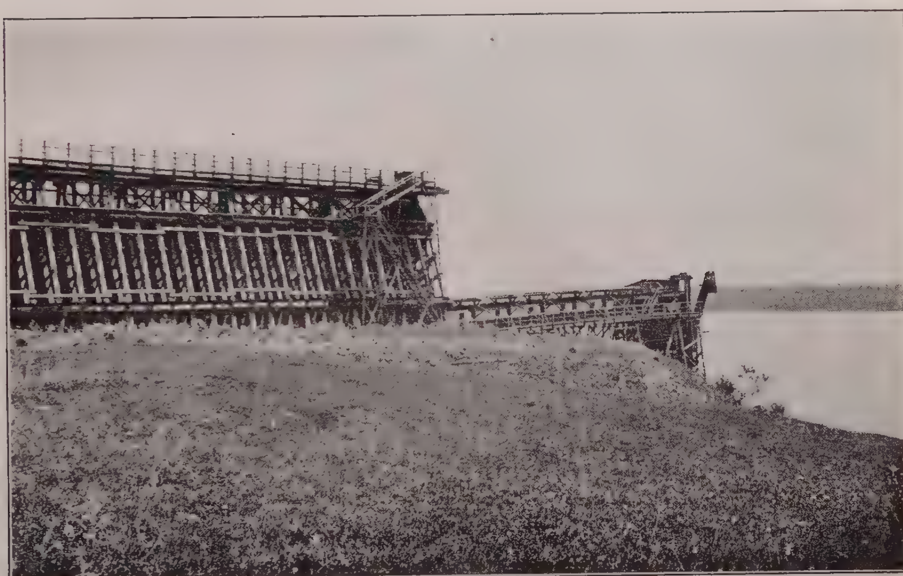
PLATE XX.

Bathurst mine, Austin Brook, N.B.

PLATE XXI.

Open-cut on No. 1 deposit, Austin Brook, N.B.

PLATE XXII.



Bathurst mines ore dock, Newcastle, N.B.

400 feet, with a maximum width at the surface of about 90 feet. Besides these two ore-bodies the magnetometric survey indicates the presence of a number of others which are all covered by humus, and on which no diamond drilling has been done.

In 1911, the ore dressing plant of the Mines Branch, Ottawa, made experiments in magnetic concentration on a 15-ton lot of Bathurst Mine ore. There was a very considerable loss of iron in the tailings due to part of the crude ore being hematite.

References:—
E. Lindeman, Mines Branch, Ottawa, No. 20.
G. C. Mackenzie, Mines Branch Summary Report, 1911, p. 61.
Information supplied by Canada Iron Corporation, Ltd., Montreal, Que.
G. A. Young, Geol. Sur. Can., Memoir No. 18 E.

NOVA SCOTIA.

Wheelock and Martin Mines.

North Range, Torbrook area, Annapolis county.

Owners: Canada Iron Corporation, Limited, Montreal, Que., (in liquidation).

In 1908 the Annapolis Iron Company became merged in the Canada Iron Corporation, the Wheelock mine becoming No. 1 and the Martin mine No. 2 mine of that corporation. During the two following years the work was chiefly confined to the development of No. 2 mine and to the building of the railway, connecting the mines with the Halifax and South Western railway at Nictaux. A shipping dock at Port Wade 55 miles by rail from the mines was also erected. The main ore-pockets at the dock have a capacity of 7,000 (long) tons. At the head of the pier a loading-pocket of 400 (long) tons capacity has been built and the ore is transported from the main pocket to the loading pocket by a bucket conveyer 1,000 feet long.

The first shipment of ore from Port Wade was made in 1910 when three cargoes of 4389, 5402, and 6499 tons were shipped to Chester, Pa., Ardrossan, Scotland, and Middlesborough, England, respectively. The average iron content of the three cargoes was about 48 per cent.

During 1910 and 1911 mining operations were continued, but, with the exception of the three abovementioned cargoes, no ore was shipped, it being found necessary to concentrate the ore before further shipment could be made. Subsequently a concentrating plant was erected at Nictaux where the large stock piles of ore which had accumulated at the mines were treated, and, during 1912 and 1913, eight cargoes of concentrates running from 50-52% iron were shipped as follows: four (23,073 tons) to Ardrossan, Scotland; two (12,429 tons) to Rotterdam, Holland; one (4,358 tons) to Middlesborough, England; one (5,676 tons) to Philadelphia. The total shipments to the end of 1913 amounted to 61,853 tons. Mining

operations ceased, however, in August 1913, and since then the properties have been lying idle.

The Wheelock or No. 1 Mine.

The Wheelock, or No. 1 Mine, is sunk on the "Shell" bed on the Fletcher Wheelock farm. It has been the chief producer on this bed, though there were a number of other openings from which ore has been shipped. It was operated from 1905 to 1908, the ore being shipped to Londonderry. In 1907 the shaft had reached a depth of 180 feet with levels at 80 and 150 feet. The 80-foot level had at that time been driven 445 feet east and 370 feet west; the 150-foot level, 280 feet east and 330 feet west.

The iron ore bed averages 7 feet in thickness, increasing to 18 feet on rolls and thinning out completely in two places where the bed takes a sudden turn. The following is the average analysis of the ore shipped:—

Iron	43·6	per cent.
Insoluble	17·4	„
Phosphorus	1·1	„

The highest average of analysis of shipments for any one month was for May, 1907:—

Iron	46·76	per cent.
Insoluble	15·19	„

The Martin, or No. 2 Mine.

This mine has been opened on the Hematite, or Leckie bed near the east boundary of the Edward Martin farm. It is situated about 2,000 feet southwest of No. 1 or Wheelock mine. The shaft is down 500 feet, with levels running off on both sides. On the west side of the shaft, the levels all measure about 300 feet in length, while on the east side the longest levels, No. 2 and No. 3, are 900 feet each. Most of the ore has been stoped out on the Hematite vein west of the shaft. East of the shaft to the depth of the 500-foot level there is approximately 115,000 tons in the stopes, probably all of which must be concentrated. The thickness of the ore varies from 3 feet 9 inches to 6 feet 6 inches, with an average of about 5 feet. The total quantity of ore raised up to August 1913, when mining operations ceased, was *102,100 tons.*

From No. 2, No. 3, and No. 5 levels cross-cuts have been driven to the Shell bed, which at this point is 100 feet to the southeast. From one of the cross-cuts a drift 850 feet long has been run on this bed, and a small quantity of ore has been mined. This level has been timbered, and stoping has been commenced.

No. 2 mine, Canada Iron Corporation, Torbrook, N.S.

The *Shell* vein has been intersected by cross-cuts on four levels from the Martin shaft and the reserve of this ore is placed at 250,000 tons.

Experiments in magnetic concentration of ores from the Shell bed and the Leckie bed made at the ore dressing plant of the Mines Branch gave unsatisfactory results, owing to such a large percentage of the crude ore being hematite.

References:—

J. E. Woodman, Mines Branch, Ottawa, No. 20.
H. Fréchette, Mines Branch, Ottawa, No. 110.
G. C. Mackenzie, Mines Branch, Summary Report, 1911, pp. 64–71.
Information supplied by Canada Iron Corporation, Limited, Montreal, Que.
C. S. Parsons, Trans. Can. Min. Inst., Vol. XVI, p. 608.

SUPPLEMENT.

NEWFOUNDLAND.

Wabana Iron Mines.

Owners: Dominion Steel Corporation, Limited, Sydney, Cape Breton, N.S.; Nova Scotia Steel and Coal Company, Limited, New Glasgow, N.S.

On Bell island in Conception bay, Newfoundland, and in submarine areas adjacent thereto are situated iron ore beds the workings on which are known as Wabana Iron Mines.

Ore Deposits.—The Wabana ore occurs in five principal beds through the upper 1,000 feet of a series of unmetamorphosed Ordovician sandstones and shales. The ore-beds outcrop for a distance of about 3 miles along the northern shore of Bell island and dip to the northwest beneath the waters of Conception bay at an angle of 8°. Only three of the ore-beds are considered of economic interest; these are the "Dominion" or "Lower," the "Scotia," and the Little Upper ore-beds.

The Little Upper bed has an area on Bell island of 70 acres. It varies in workable thickness from 5 to 8 feet, and averages about 6 feet. The ore varies in quality from 56 per cent iron in the upper portion, to 51 per cent iron in the lower section of the bed, and the silica content varies from 6 to 10 per cent.

The "Scotia" bed lies 50 feet below the Little Upper bed. It varies in thickness from 7 to 9 feet and contains 53 to 56 per cent iron, 7 to 9 per cent silica, and 0·80 to 0·90 per cent phosphorus.

The Lower or "Dominion" bed is situated 243 feet below the "Scotia" bed. At the surface it varies in thickness from 8 feet at the eastern to 14 feet at the western outcrops. In the underground workings the thickness ranges generally from 12 to 20 feet, though at one point in the submarine workings a thickness of 33 feet has been proven. Through the entire explored area this bed has an average workable thickness of 16 feet. To the end of 1913 the ore recovered from the open-cut workings on this bed had amounted to 4,347,150 gross tons.

The iron content of the ore mined from the land areas of the Dominion bed varies from 50·50 to 53·0 per cent, silica from 10·5 to 14·0 per cent, and phosphorus from 0·70 to 0·85 per cent. At distances of 4,000 to 8,000 feet from shore the ore has been proven by a few drill holes to be thicker than on the land areas and to be of slightly better grade.

Physical Characteristics of the Ore.—The ore from all the Wabana beds has the reddish-brown colour typical of amorphous hematite, a fresh fracture presenting a reddish-grey colour with submetallic lustre. When shattered the ore breaks readily into parallelopiped-shaped blocks, these being seldom

larger than 8 inches square or smaller than $1\frac{1}{4}$ inches square. The specific gravity is high and the ore in place will average about 9 cubic feet to the ton.

The ore is composed of two principal iron-bearing minerals, hematite and chamosite, while a third, siderite, becomes locally abundant. Quartz is present in some quantity in small fragments scattered throughout the ore.

Chemical Analyses.—From the iron and phosphorus contents of the ore-beds mentioned above it will have been noted that the Wabana ore is all of *non-bessemer grade.* The following is a typical analysis (Cantley 1911) of ore from the Scotia beds:—

Iron	53·86	per cent.
Silica	9·48	„ „
Sulphur	0·018	„ „
Phosphorus	0·850	„ „
Alumina	3·55	„ „
Lime	1·81	„ „
Magnesia	0·84	„ „
Manganese	0·65	„ „
Loss on ignition	4·32	„ „

The average analysis of 220,000 tons shipped by the Nova Scotia Steel and Coal Company to Philadelphia in 1910, and the average analysis of the aggregate shipments by the same company in the years 1910, 1911, and 1912, are given herewith:—

	1910 shipments to Philadelphia.	Total shipments 1910, 1911, 1912.
Iron	53·71 per cent.	51·88 per cent.
Silica	......	9·56 „ „
Phosphorus	0·868 „ „	.....
Moisture	2·31 „ „	.....

Ore Shipments.—The total ore shipments from Wabana mines from 1909 to 1915, inclusive, amounted to 7,140,046 gross tons. From the commencement of mining operations in 1895 to 1909 one of the operating companies (Nova Scotia Steel and Coal Company) had shipped 3,405,588 gross tons. The aggregate shipments to the close of 1915 were in excess of 13,000,000 gross tons.

From 1909 to 1915 inclusive the amount of Wabana ore shipped to blast furnaces in Nova Scotia was 4,806,277 gross tons (5,383,030 short tons), and this amount represents almost the entire consumption of the Nova Scotia furnaces for the period mentioned.

Ore Resources.—Any estimation of the total amount of ore present in the Wabana deposits depends largely on an interpretation of the structure

of the ore-strata and hence must be largely hypothetical. The only known data are the lengths of the outcrops on Bell island, the section given by the submarine slopes with a length of about 10,000 feet, and the thicknesses of the beds shown in the underground workings. From these data Elwin E. Ellis has estimated the reserve of ore of present commercial grade as 3,250,000,000 tons, allowing for workings 5 miles long; Edwin C. Eckel in his book on "Iron Ores," p. 378, gives the reserve of economically available ore as 2,600,000,000 tons. Both Ellis and Eckel, and other engineers as well, believe that the tonnage of ore in the beds may far exceed the figures given above but that the reserve tonnage will in all likelihood be determined by working conditions and cost rather than by the exhausting of the ore-beds.

The Wabana ore-beds are of a higher grade in iron than most other sedimentary ores; the total tonnage present makes up one of the very largest, and by far the most compact ore reserves in the world; and in spite of the fact that the bulk of the tonnage is submarine the ore can be placed in any Atlantic port of America or Europe at a cost far lower per unit of iron than any competitive ore. In summing up the extent and control of the world's iron ore reserves Eckel says (p. 425) "the 4,000,000,000 tons of Newfoundland ore may be the most important single factor in our next stage of progress, for, as soon as an ore-holding reaches a size to justify changes in metallurgical practice or plant location, its ores acquire a technical and moral value far above that which they would have if merely sold on a competitive basis in an open market."

Ownership of Ore Deposits.—The Wabana ore deposits are owned by two companies, the Dominion Steel Corporation, and the Nova Scotia Steel and Coal Company, both Canadian companies, with their blast furnaces, and steel mills in Canada. The Dominion Steel Corporation owns the Dominion bed on Bell island, and all the ore-beds in a submarine area of 3½ square miles adjacent to the north shore of the island, and in a second submarine area (of 2½ square miles area), farther from Bell island. The Nova Scotia Steel and Coal Company own the portions of the "Scotia" and Little Upper beds on Bell island, and all the ore in submarine tracts with an area of 82½ square miles, the most easily accessible of the latter being about 4,000 feet from Bell island, and now being operated by a slope driven through the Dominion Steel Corporation's larger submarine area.

Mining Operations of the Dominion Steel Corporation.

The mining operations of the Dominion Steel Corporation have as yet been restricted to their land areas. Several quarries and slopes have been operated. The underground mining is carried on under a modified system of room and pillar, rooms 25 feet wide being driven from the slopes at 50-foot intervals. The output of ore can be maintained at upwards of

5,000 tons per day, and when submarine mining is commenced a like tonnage can be hoisted through the slopes already driven through this ground by the Nova Scotia Steel and Coal Company.

The ore is crushed to pass a 5-inch ring and is cobbed on picking belts before going to stock piles or ore bins. The haulage from stock piles or ore bins to the shipping pier is done by an endless cable system capable of handling over 5,000 tons per day. The pockets for storage of ore are located close to the pier and have a capacity of 23,000 tons. The bucket conveyers for conveying the ore from the storage pockets to the pier handle from 2,200 to 2,500 tons per hour. Cargoes of 10,000 tons have been loaded in 4½ hours. The pier is located on the south side of Bell island where good protection is afforded and where there is sufficient depth of water to permit the largest of ocean freighters to safely tie up.

In 1914, the Dominion Steel Corporation estimated the tonnage of ore economically available in their land areas as 21,500,000 tons, and in their submarine areas as 120,000,000 tons.

Mining Operations of the Nova Scotia Steel and Coal Company.

The Nova Scotia Steel and Coal Company have extracted all the ore in the portion of the "Scotia" bed on Bell island except the pillars, which can be broken down when the ore of the Little Upper Bed, 50 feet above, is all mined. Work on the latter was commenced in 1914. The submarine areas were tapped in 1908 and by the close of 1911 the main slope had been extended 3,600 feet into this territory. The submarine areas were, as rapidly as possible, put in shape for producing tonnage, and since 1911, all ore shipped has come from them.

From the main slope (with a section 8 feet by 16 feet), which followed the "Scotia" bed, drill holes were put down to test the "Dominion" bed in the submarine areas of the Nova Scotia Steel and Coal Company. As the drilling proved the latter to be thicker and of better grade than in the land areas the dip of the slope was increased from 8° to 30° so that the slope would cut the "Dominion" bed. The latter bed was reached by this slope in December 1910 and is reported to have proved up to expectations.

A commencement has also been made on sinking two deep slopes from points south of the outcrop of the "Dominion" bed on Bell island. These will be driven below the lowest ore-beds of the Dominion Steel Corporation's larger submarine area to reach the Nova Scotia Steel and Coal Company's submarine area already penetrated by the upper slope.

In the underground workings the room and pillar system, with modifications, is used in extracting the ore, and shovelling machines are used for loading the ore cars.

The hoisting is done in 20-ton cars and the equipment is designed to handle 3,000 tons per day. During 1913 and 1914 the actual daily average

hoist approximated 2,000 tons per day. After reaching the surface the ore passes over picking belts both before and after being crushed.

A double track tramway operated by an endless cable is employed to move the ore from the deckhead or stock piles to the storage bins situated close to the shipping pier. The capacity of the haulage system is 3,000 tons per day.

The ore pocket, which occupies a ravine in the rocky coastline holds 40,000 tons and this, with the pockets on the pier, gives a storage capacity of 60,000 to 70,000 tons. The ore is conveyed from the storage pocket to the pier by an endless bucket conveyer. Improvements in the haulage and loading facilities made in recent years have made possible the loading of boats at a rate exceeding 5,000 tons per hour.

Practically all pumping, haulage, crushing, ventilation, etc., are done by electric power. The power is generated at a power house erected close to the shipping pier where it may easily be supplied with coal brought from the company's properties in Nova Scotia.

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